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THE CELEBRATION IN HONOR OF EMPEROR WILLIAM THE GREAT.

THE hundredth anniversary of the birth of Emperor William I awakens many memories of him about whose picture tradition has already begun to weave all sorts of wonderful tales, and who still lives for the younger generation because of these stories and songs. We publish a series of illustrations showing mementoes of him, and also a view of the grand monument that has been erected in Berlin to his memory.

After his death New Germany wanted to erect in its capital a monument that would be entirely worthy of dedication to its first Emperor and in which the whole nation should be interested. Competitive designs were called for, but the work was finally put in the hands of Prof. Reinhold Begas, in accordance with the wishes of the present Emperor, and it was decided that no more fitting day could be chosen for the unveiling of this monument than the 22d of March, when all of Germany would be celebrating the hundredth birthday of their beloved Emperor.

After the artist had been chosen it was necessary to decide upon a site for the monument, and after consideration a row of houses between the old palace and the Spree was torn down to make room for it, so that it should be near Berlin's celebrated avenue, Unter den Linden, the historic old palace, the museum, the arsenal, and not far from the old Emperor's own palace. The monument is 72 feet high, about as high as a house, and all its dimensions are very large, so that it had to be treated in masses; but it was most skillfully handled by Begas, who was assisted by young artists. Begas has put his best work into this monument, which is so clearly shown in the accompanying

CORONATION ROBE WORN IN 1861.
(FROM THE HOHENZOLLERN MUSEUM.)

ARTICLES USED BY EMPEROR WILLIAM I.
(FROM THE COLLECTION OF G. SCHWEITZER.)

THE CENTENNIAL ANNIVERSARY OF THE BIRTH OF EMPEROR WILLIAM—MONUMENT ERECTED IN BERLIN AND DEDICATED ON MARCH 22, 1897.—BY REINHOLD BEGAS.

PICTURE AND ARTICLES OWNED BY EMPEROR WILLIAM I.
(Collection of G. Schweitzer.)

engraving that a description of it seems quite unnecessary.

The mementoes shown in our other engravings belong partly to the Hohenzollern Museum and partly to private collections, chief among which is that of George Schweitzer, of Berlin, who for twenty years past has lovingly collected all he could get that related directly or indirectly to Emperor William I. The young Prince's note book, shown in one of our engravings, carries us back to his childhood. In this he tells of a present received from his tutor, Delbrück, on his birthday, and in it he also drew an ink sketch of Königsberg Castle, in January, 1807. At the left of the same engraving we find his first reading book, published at Frankfort on the Main, in 1802, and entitled "Kleine Plaudereien für Kinder, welche sich im Lesen üben wollen, von Löhr." The tutor above referred to wrote on the flyleaf the date on which the Prince read a story in the book without previous instruction, and read it very well. This little book was given to Emperor William on his eighty-second birthday by his brother Karl, who used it after he was through with it.

The steel watch chain, shown in the center of the engraving, was the first one worn by the Prince; according to the note written in his own handwriting, he wore it from 1812 to 1822, during campaigns and on journeys. The hymn book with the crucifix was used by him during the latter years of his life, and the porcelain cup and saucer were in daily use for over forty years. At the right and left are wooden and plaster toys that he once played with. The onyx-topped table under the hymn book is from St. Cloud, and on it Napoleon wrote the declaration of war against Prussia. We also show the mantle worn at the coronation of the King on October 18, 1861. It is of heavy purple velvet, richly embroidered with crowns and eagles, and is lined with ermine.

The articles belonging to the collection of G. Schweitzer, and shown in another engraving, remind us of the soldier and hunter. There is the coat of the First Foot Guards, often worn by the Emperor, with epaulets bearing the insignia of the highest military rank—two marshal's staffs and three stars; another epaulet and a shoulder strap lie below it. At the left we see the much-worn soldier's cap, and at the right the hunting cap of gray cloth. The simply cut cane was used by the Emperor in his walks in Babelsberg. Below are the various articles contained in the traveling case that accompanied him on all his journeys for over twenty years. In another engraving we find a very good portrait of the Emperor, taken in 1866, with the Hradschin at Prague in the background. This picture hung in the Emperor's sleeping chamber in the Berlin palace. The excellent portrait of him shown at the left of the engraving was on a sweetmeat box used on the table at a court celebration—as indicated by the inscription—of the ninetieth birthday of the Emperor, and the contents were distributed by him personally. The bows are made of the German colors, and the crowns in the corners are of metal. Near by is one of the Emperor's stockings on which the letters "P. v. P." (Prince of Prussia) are embroidered. The blue and white striped cravat shows the care that the Emperor gave his things. Next it is a stone that he, then only seventeen years old, carried away from the battle field of Bar sur Aube, February 27, 1814. It was the same battle in which he won the Russian Cross of St. George, for his coolness and courage, which he always wore with his Prussian military orders. All of these things that were used by the Emperor will have a special interest for the many all over the world who remember him with love or respect.

For the accompanying engravings we are indebted to our contemporary, Ueber Land und Meer.

THE POPE'S ARMY.

The following particulars of the Pope's army are supplied by a Roman journal. It is divided into five separate bodies—the Noble Guard, the Swiss Guard, the Palatine Guard, the Gendarmes, and the fire brigade. The Noble Guard is commanded by Prince [illegible] and is composed of fifty young members of the Roman nobility. Each member of the corps receives from three to four hundred lire a month and a special club is maintained for their use. The Swiss Guard is one hundred strong, and the men are specially selected for their youth and strength. They guard the doors and entrances of the Vatican, and are armed with the Remington rifle. On parade they carry the halberd. The Palatine Guard is divided into two companies commanded by General Erostarosa, who has under him a staff of two majors and four captains. This corps, raised from citizens of Rome, is called out only on special occasions. The gendarmes number one hundred, un-

ARTICLES USED BY EMPEROR WILLIAM I. (From the Hohenzollern Museum.)

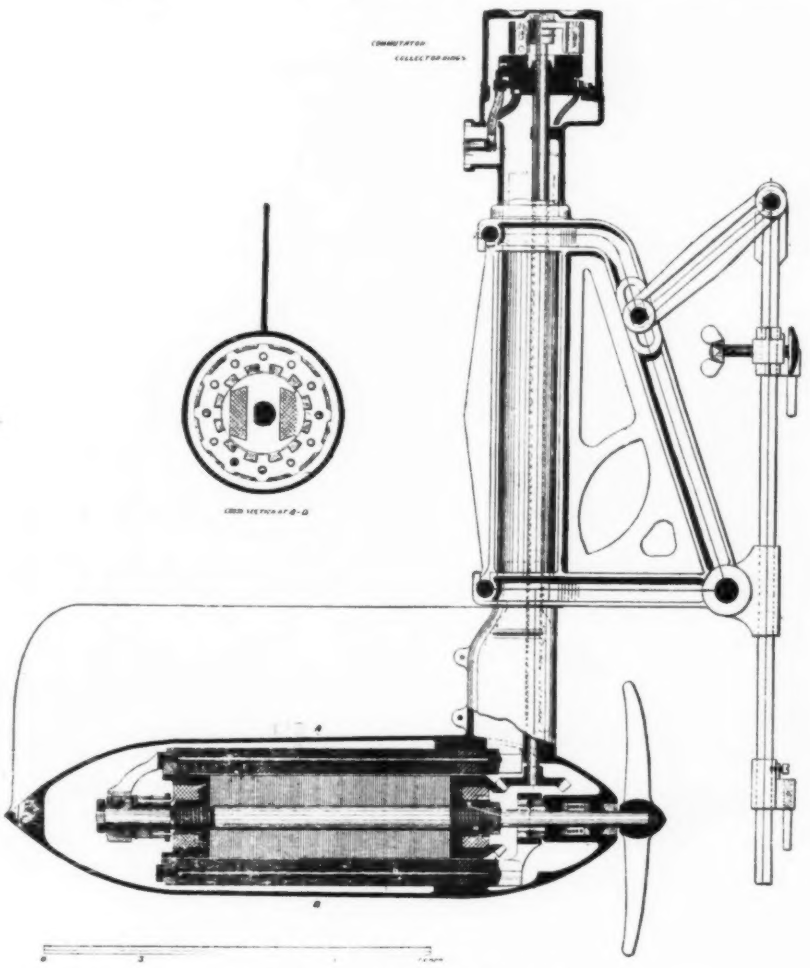
der the command of Colonel Tagliafetri, and are recruited from ex-soldiers of the Italian army, specially recommended by Italian Bishops for their religious fidelity and fervor. The firemen, or pompiers, number thirty, and are always in the Vatican. The Pope's army has its special daily journal, the Fedelta Cattolica.

THE DEVELOPMENT OF THE RUDDER MOTOR.

WE have on various occasions commented on the use that was being made of electric motors for propelling boats, and we have particularly referred to what is known as the rudder motor. It is obvious at the first glance that the main essential in an appliance of this description is extreme lightness, coupled with a moderate electrical efficiency. Even the makers do not claim that the vessels to which such mechanism can be applied are more than of moderate size, and it is clear that the use of a rudder motor has distinct limitations. But within these limitations there is abundance of scope for so ingenious a contrivance. The special feature of the rudder motor is that it may be applied to skiffs, punts, dinghies, without in any way altering their construction, and this is a feature that should appeal to all classes of the great boating public. Even a rowing man will appreciate it, while it may even tend to eliminate that great scourge—the man who can't row. It permits to the fullest extent of that delicious idling which is the very essence of up-river life; and it will enable one to cover a distance within a certain time that has been hitherto possible of accomplishment by only steam or electric launches.

The rudder motor is by no means new to the river; indeed, it has been to some extent in use for two or three seasons, but the experience that has been gradually accumulated of the performance of this type of propeller has enabled the inventors or promoters to carry out so many improvements that lead one to think that they have arrived at a really practical appliance.

We have recently had an opportunity, says the Electrical Review, of London, of examining the latest type of rudder motor made by Messrs. New & Mayne, and it must be admitted that it is vastly superior to the previous type; it is not so much that the main features of the invention have been altered, but rather that the construction and arrangement of the various parts have been improved.



DETAILS OF RUDDER MOTOR.

The rudder motor consists of an electric motor specially constructed in the shape of a small torpedo; it was this peculiarity that filled a good sized policeman with alarm when he viewed a rudder motor at Westminster Bridge. The necessary conductors are conveyed from the yoke or tiller bar through the supporting tube, which forms part of its construction. The rudder is fitted with an adjustable frame which enables it to be attached to any boat, but the yoke, or tiller bar, and adjustable frame are easily detached from the motor as well as the propeller. The rudder is provided with rudder lines, which terminate in metal plugs, and these fit into sockets provided on the switch inside the boat; these lines not only serve for steering, as in the ordinary way, but also make the necessary electrical connection between the switch and the motor. A small propeller is fitted on a projecting shaft at the end of the torpedo, and when in place on the stern of the boat lies close up to the keel. This propeller revolves at a high speed when current is supplied to the motor, and it is this which drives the boat. The motor itself is also fitted with a thin metallic fin, which enables the rudder to be used in the ordinary way when sailing or rowing. The pivoted point of the motor is where the supporting tube passes through the frame to the yoke, and this takes an ample bearing in the frame, thus avoiding any vibration. The frame is fitted with two thumbscrews, which press small pads against the stern of the boat, and hold it perfectly rigid. It is claimed that, as the propeller moves with the motor, extremely sensitive steering is obtained when the motor is running, and thus the most complete control and maneuvering power to the operator is secured.

The peculiarity of the motor, from an electrical point of view, is that the field magnet revolves inside the armature, which is, of course, of circular shape. The field magnet, which is the revolving part of the mechanism (see drawing), drives, through bevel gearing, a vertical shaft, which passes up the supporting tube already mentioned. The connections from the sections of the armature are taken up the interior of the tube to the segments of the commutator, which is fixed at the top of the vertical shaft. The commutator, however, is not in direct connection with the revolving vertical shaft, and is moreover stationary, the necessary commutation being done by the revolution of the brushes, which are carried on a projection of the vertical shaft. In spite of the arrangement of the electrical parts, the electrical efficiency of the motors is fairly high. The improvements that have been made are in the better support of the apparatus, and a more mechanical arrangement of the working parts. The armature and field coils are insulated by a patented waterproof composition giving an extremely high insulation resistance, so that any danger of breakdown through "earths" is averted. We are informed that tests of over 500 megohms insulation resistance have been obtained on many of these machines.

The motor is, of course, driven by secondary cells, and there is on each boat a regulating and reversing switch. We saw a skiff being driven by the motor a few days ago, and as far as we could see from a short inspection, the various evolutions of the boat were rapid. The weight of a ½ horse power motor is about 55 lb., and a 2 horse power 200 lb., this, of course, being exclusive of batteries and switching gear.

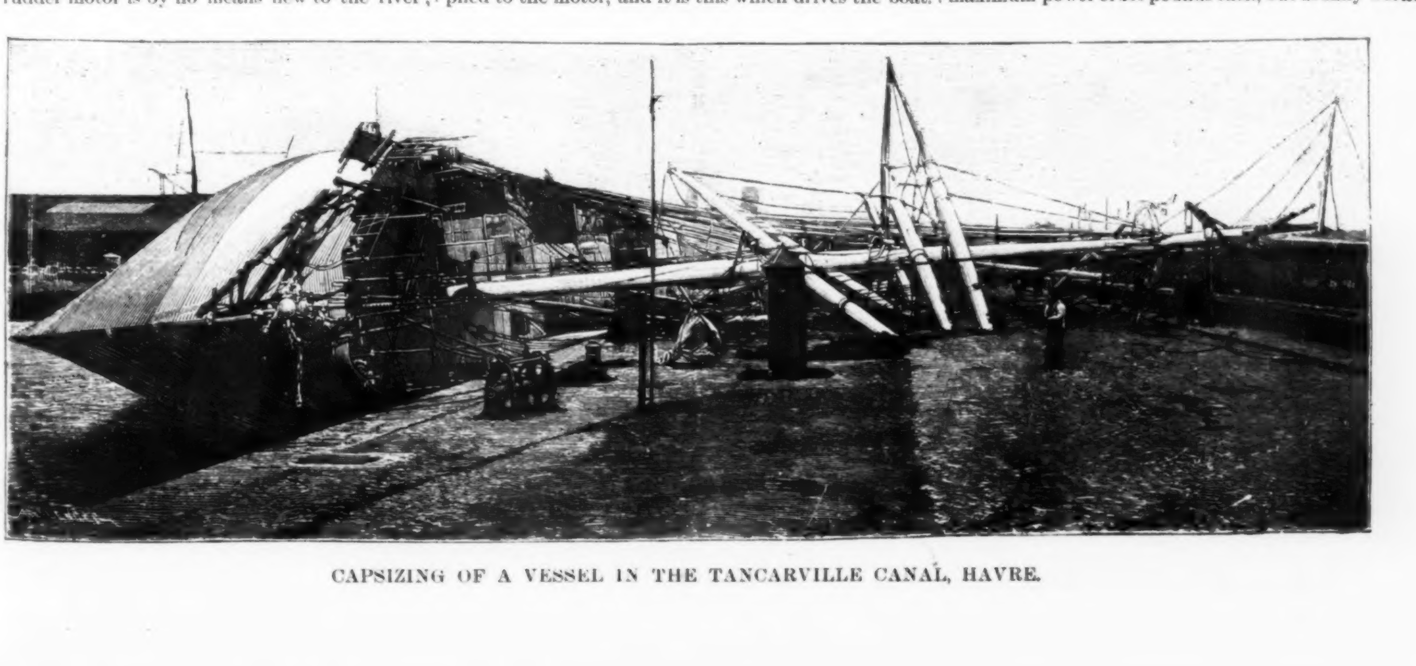
THE CAPSIZING OF A SHIP.

AN accident of an uncommon character occurred on January 21, at 10 o'clock in the morning, in the Tancarville Canal at Havre. The French three-masted vessel Jacques, launched at the Mediterranean shipyard at Graville, capsized at the moment at which the lock gates were being opened. The vessel, which carried very heavy masts and was not as yet ballasted, careened very greatly to an angle of 45° through the pull of its moorings, which were tautened by the change in the level of the water. Then all at once, with a fearful crash, it fell upon the Seine quay, the masts breaking the grates that surround the dry dock. On board, there was a scramble for safety. The forty men who were at work fled in terror. The water, moreover, entered through the scuttles. One man jumped into the water and reached the wharf through swimming. Another, a carpenter, had his foot squeezed and nearly broken. A fire broke out from the upsetting of a stove, but the firemen could not go aboard.

The first moment of paralyzation having passed, the roll was called, and fortunately no one was found to be missing. After several fruitless tentatives, the ship was finally righted. The loss amounted to $7,500. The Jacques is a very fine type of steel vessel. She is 249 feet in length and of 38 foot beam.—L'Illustration.

PIPE LINE SYSTEM OF DRAWING WATER FOR FIRE SERVICE.

SOME of the Eastern cities have lately been investigating, through their official and engineering experts, the merits of the pipe line system in Detroit and other Western cities for drawing water for fire service from rivers and the great lakes, says the Boston Journal of Commerce. The system in Detroit consists of fourteen lines of eight inch steel pipe which has been subjected to a test of 1,000 pounds hydraulic pressure. These are laid underground at depths varying from four to twenty-two feet, according to grade, and carry water from the Detroit River to hydrants having a six-inch stand pipe with two three-inch and one four-inch outlets each, the hydrants being seventy-four in number, and located with more or less regularity over the district. Pressure is afforded by a fire boat, which has two pumps with a maximum power of 250 pounds each, but usually worked



CAPSIZING OF A VESSEL IN THE TANCARVILLE CANAL, HAVRE.

at 180, a speed of twelve miles an hour having been attained by this craft. Connection with the boat is obtained at the river through a three or five way siamese, with three and one-half inch openings and a clack valve over each, and placed at the harbor terminus of every pipe line, and the boat can start its pumps as soon as the first connection is made. Brick manholes are built opposite each hydrant, and a wire running alongside the main pipe from the river to each hydrant enables communication to be made by signals between the scene of a fire and the boat.

THE EVOLUTION OF THE AMERICAN LOCOMOTIVE.

By HERBERT T. WALKER.*

To write a short article on the evolution of the most scientific and wonderful form of the steam engine is not, by any means, an easy task; for not only is the quantity of information on the subject enormous, but it is scattered over a vast area, which makes it difficult to collect and classify and still more difficult to condense and present to the average reader in a way that shall be interesting without going too much into technical details.

It is to be deplored that no history worthy the name has yet been written of the American locomotive. Many short articles and fragmentary accounts of certain old engines have appeared in technical periodicals and some books have been written describing engines of a certain period, or those constructed by a particular firm of engine builders, but, valuable as these works are, none of them have attempted to deal with the subject in either a comprehensive manner or from an impartial standpoint.

Probably the best outline history of the American locomotive will be found in the opening pages of Zerah Colburn's "Locomotive Engineering and Mechanism of Railways," 1871. This is a standard English text book, and it is worthy of note that Mr. Colburn was an American.

The want of a good history is to be further regretted for the reason that drawings of many important locomotives have now become destroyed or lost and their designers and builders have since passed away. An illustration of this point can be made by quoting a passage from a letter received by the author from one of the largest locomotive works in America, in response to a request made by him for certain information: "We can find no drawings or tracings of the engine you refer to. At the time that engine was built full sets of drawings were probably never made. Full size sketches on boards were often made use of for important parts, sometimes half size on long rolls of paper, and the minor parts, even boilers, were made from pen sketches. Many of the half size drawings on paper, of the engines built in early days, have been defaced, torn and thrown away many years ago."

Even in cases where drawings have been preserved they have been found to be incorrect in details, because complete plans of many engines were never drawn, or if they were, alterations and additions were made during the building of the engines without such changes being noted on the drawings. This is a fault that even modern engineers and draughtsmen are not free from.

In the present article an attempt will be made to trace the progress of the American locomotive from the crude machine of about ninety years ago to the magnificent engine of modern times, passing but lightly over all sporadic or transitory forms and dealing principally with some of the earliest engines possessing details of construction that go to make the locomotive of the present day a mechanical and commercial success.

Richard Trevithick, of Cornwall, England, was undoubtedly the father of the locomotive. In the year 1803 he built a tramway engine having a horizontal cylinder connected by gear wheels to the driving wheels; he employed high pressure steam and turned the exhaust steam into the chimney by means of a pipe which he called the "blast pipe." On February 24, 1804, this engine was tried on the Penydarran tramroad, in Wales, and conveyed a load of ten tons of bar iron and about seventy passengers to Merthyr Tydvil, a distance of nine miles. The locomotive worked satisfactorily from a mechanical point of view, but commercially it was not a success, being more expensive than horse traction.†

No essay on our subject would be complete without mentioning the name of Oliver Evans, although his machine was not, strictly speaking, a locomotive engine, but it was the first carriage propelled by steam in America. The name of this curious machine was Eructor Amphibolis, and it was built for dredging purposes, being mounted on a scow or lighter having four carrying wheels. The engine had a walking beam and fly wheel communicating motion to the carrying wheels by rope gearing. Evans was thus enabled to transport the machine by its steam power from his shop in Philadelphia for some distance over rough roads to the river Schuylkill, which it navigated (by means of a paddle wheel) to its mouth, whence it ascended the Delaware to a point where it was set to work dredging.‡ This was in the year 1804, and for the next twenty years Blenkinsop, Hedley, Hackworth and Stephenson were bending all their energies to develop practical locomotives.

The next attempt at steam locomotion in America appears to have been in the year 1825, when Col. John Stevens, of Hoboken, N. J., designed and built a rack rail engine for the purpose of exhibiting to a committee of the Pennsylvania Society for Internal Improvement when the question of constructing a railroad from Philadelphia to Columbia was being considered. This was the first steam engine that carried passengers on a track in the United States, and is shown in Fig. 1.

The following extract from a letter dated March 30, 1883, from Mr. F. B. Stevens (Colonel Stevens' grandson) addressed to Mr. J. E. Watkins, Curator of the National Museum, Washington, describing the locomotive of 1825, will be of interest:

"The track was laid on wooden stringers capped with thin iron, the gage being about that usual on ordinary roads or turnpikes. A cast iron rack was laid in the center of track, and into the teeth of this rack a cog wheel, driven by the engine, geared. The engine had only a single cylinder, which was exactly horizontal, resting on the main frame and was from four to five inches in diameter and about one foot stroke. The boiler was formed by a number of vertical tubes each about $1\frac{1}{4}$ inches external diameter and $4\frac{1}{2}$ feet long. These tubes were set closely together in a circle, surrounding and inclosing a circular grate of about ten inches in diameter. This boiler was inclosed by a jacket of thin sheet iron, which was surmounted by a conical hood on which the smoke stack rested. The fuel was wood, which was dropped on to the grate through a door in the hood. The boiler with its jacket and stack presented very much the outside appearance of the small vertical flue boilers now in use.

"The engine was set on four wooden wheels about four feet in diameter.

"I have an impression that friction wheels of small diameter and having their axes vertical were used to keep the engine on the track, but my recollection is not at all distinct on this point. The tires were without flanges, the wheels being the ordinary wagon wheels."

A full size model of this engine was shown at the Columbian Exposition of 1893 with the tubes placed outside for the purpose of exhibition, as seen in the illustration.

But the first practical locomotives were imported from England. With however much pride (and justly) we Americans may point to our modern engines, some of which are the fastest and most powerful in the world, we must not forget that the cradle of the locomotive was in Great Britain, and that long before any such machine was seen in this country, stalwart mechanics on the bleak hills of northern England and Wales had sweated and toiled their lives away in the face of difficulties and discouragements of which we know nothing; and, with scarcely one of the appliances now commonly found in machine shops, had produced successful locomotives for hauling coal and freight trains. In the year 1825 the Stockton and Darlington Railway was opened for traffic, with George Stephenson's engine Locomotion, and from that time the steam passenger railroad was an established fact.

From Stretton's valuable and interesting book, "The Locomotive Engine and its Development," we learn that early in the year 1828 the Delaware and Hudson Canal Company, having heard of the success of the Stockton and Darlington Railway, sent Mr. Horatio Allen over to England with instructions to obtain information and purchase rails and locomotives. He placed orders for some engines with Messrs. Foster, Rastrick & Company, of Stourbridge, and also with George Stephenson. Stephenson's engine was named America; it was built in 1828, and arrived in New York on board the ship Columbia about the middle of January, 1829. It was the first practical locomotive seen in this country and is illustrated by Fig. 2, which is a copy of one of Stephenson's working drawings. Although this engine was the first to arrive, it was not

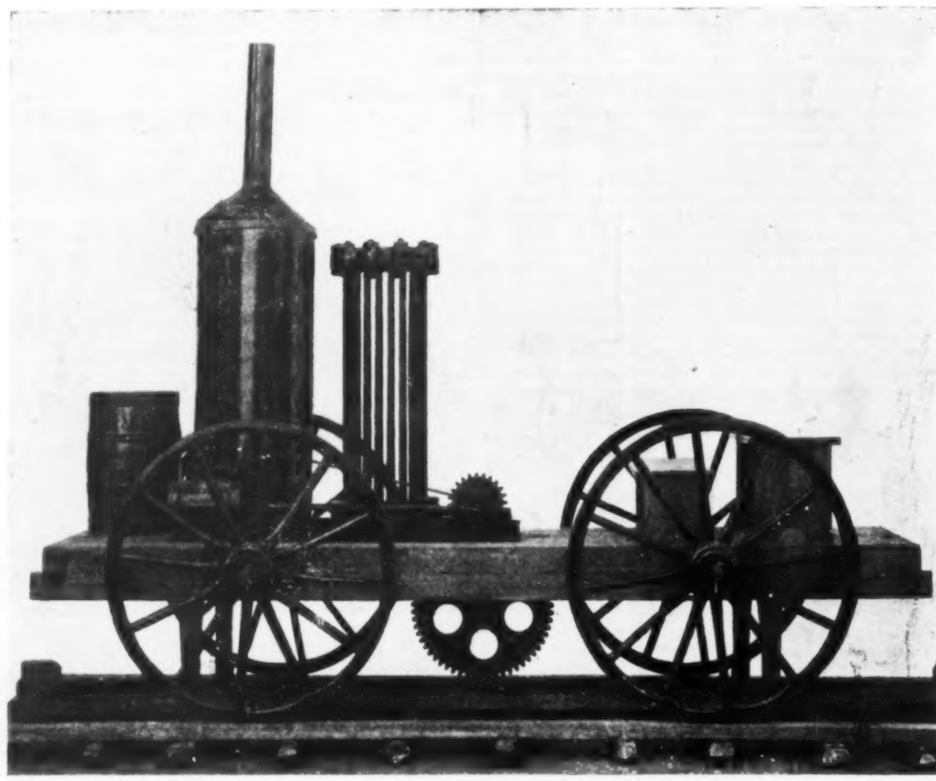


FIG. 1.—STEVENS' RACK RAIL ENGINE, 1825—FIRST ENGINE TO CARRY PASSENGERS ON A TRACK IN THE UNITED STATES.

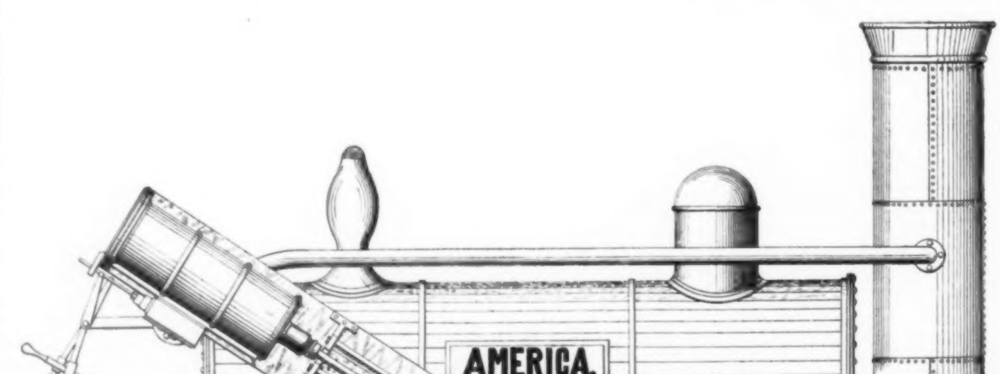


FIG. 2.—STEPHENSON'S ENGINE FOR THE DELAWARE AND HUDSON CANAL COMPANY, 1828—FIRST PRACTICAL LOCOMOTIVE SEEN IN THE UNITED STATES.

* Member of the National Railway Museum Committee (England).

† This engine was illustrated in the SCIENTIFIC AMERICAN SUPPLEMENT, April 7, 1894.

‡ This engine was illustrated in the SCIENTIFIC AMERICAN, April 3, 1847.

the first to be used, as will be seen later on. Following are some of the principal dimensions of America: Diameter of boiler, 4 feet 1 inch. Length, 9 feet 6 inches. Dimensions of fire place, 4 feet by 3 feet. Diameter of cylinders, 9 inches by 24 inch stroke. Wheels (wood), diameter 4 feet. Angle of cylinders to the horizontal, 33°. Diameter of tubes, 1 foot 7 inches. Number of tubes, 2. It had no smokebox, the two fire tubes opening directly into the chimney base.

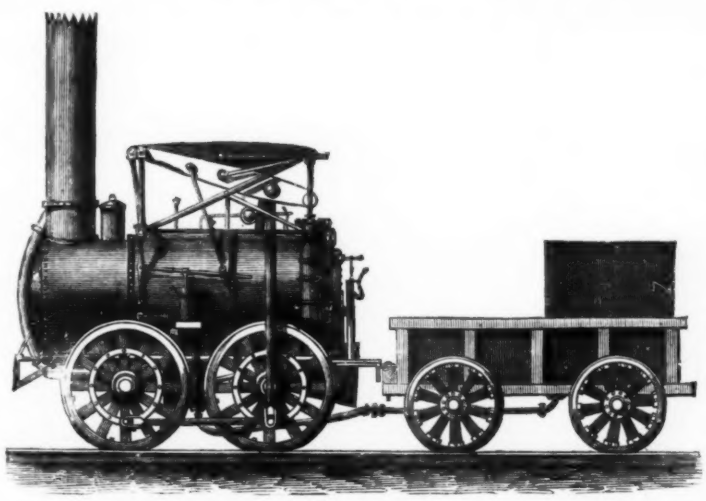


FIG. 3.—STOURBRIDGE LION, DELAWARE AND HUDSON CANAL COMPANY, 1828—FIRST PRACTICAL LOCOMOTIVE TO TURN A WHEEL IN THE UNITED STATES.

All the early engines designed by Stephenson had frames made of bar iron, but about the year 1826 he adopted a composite frame; the frame connecting the wheels and supporting the boiler being of bar iron as usual, with the addition of a plate iron frame carrying the cylinders and motion, as seen in America. While this construction possesses grave faults, it illustrates a step in the evolution of the locomotive frame, for in 1830 Stephenson abandoned the bar frame and introduced a double plate frame with an oak beam fastened in between the plates. This was called the "sandwich" frame and was used in England for many years, until the oak filling was finally discarded and the frames made of iron plates alone. Thus, the plate frame of the English locomotive of to-day is a development of the cylinder frame of America. On the other hand, American builders, while they used the sandwich frame to a limited extent, soon selected the bar frame as better adapted to American requirements on account of its superior flexibility on a rough track and comparative low cost, and this bar frame is one of the chief characteristics of the modern American locomotive.

Messrs. Foster & Rastrick's engine, the Stourbridge Lion, is shown in Fig. 3, and was also built in 1828, arriving in New York May, 1829. It was tried for the first time August 9, 1829, being driven by Horatio Allen on a section of the Delaware and Hudson Canal Company's railroad and was the first practical locomotive ever run on a railroad in America. As it was too heavy (7 tons) for the very light track of that period, it was soon withdrawn from traction service. The boiler was tubular and the exhaust steam was carried into the chimney by a pipe in front of the smoke box, as shown. It had vertical cylinders of 36 inches stroke, with "grasshopper" beams and connecting rods, thereby imparting an up and down movement to the driving wheels, a serious defect in a locomotive, as a vertical pull on the cranks is hard on the track and makes the engine unsteady.

In this respect also Stephenson's America (Fig. 2) is

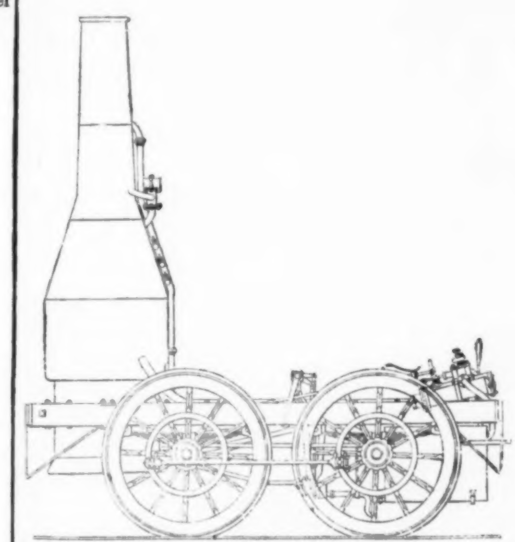


FIG. 4.—THE BEST FRIEND, 1830—FIRST LOCOMOTIVE BUILT IN AMERICA FOR ACTUAL SERVICE—SOUTH CAROLINA RAILROAD

worthy a little study, as it is one of the earliest improvements he made in the locomotive engine. It will be seen that the piston rods communicate motion to the cranks by connecting rods without any intermediate gearing (this plan was first used by him in the year 1826), and thus we have one of the earliest examples of a direct connected four coupled engine as now in use all over the world.

We now come to the year 1829, which was a memorable one in railway history, but before describing the principal event of that period, it is necessary to note in passing that Peter Cooper built an experimental engine

ENGINE 999—1893. THE DE WITT CLINTON—1831.

FIG. 5.—THE FIRST AND LATEST ENGINES FOR THE NEW YORK CENTRAL AND HUDSON RIVER RAILROAD.

named Tom Thumb. This engine had an upright boiler 20 inches in diameter by 5 feet high, with gun barrels for tubes. It had a single cylinder 3¼ inches diameter by 14½ inches stroke. This engine was tried August 28, 1830, on the Baltimore and Ohio Railroad, and with a load of 4½ tons it made 13 miles in 1 hour and 15 minutes, the best time for a single mile being 3¼ minutes.

In the year 1829 George Stephenson placed his world renowned Rocket on the tracks of the Liverpool and Manchester Railway. Although this was only about a year after America was built, the Rocket was a vast improvement on that engine, having a multitubular boiler (tubes were of copper) with a fire box riveted to the end thereof, and surrounded with water, inclined cylinders with direct connection between the piston rods and crank pins on a single pair of driving wheels, and the exhaust steam was turned into the chimney through a blast nozzle. In short, it possessed all the essential features of the modern locomotive.* At the celebrated Rainhill trials, commencing October 8, 1829, it attained a maximum speed of 24 miles an hour, and is credited with covering a mile in 60 seconds when running without a train.

This engine is preserved in the South Kensington Museum, London, and is generally regarded as the most interesting locomotive in the world, not only for the reasons above named, but also for the fact that its success went a great way to silence the opposition to railways; an opposition that is hard for us to realize at the present day. The early locomotives were contemptuously called "steam pots," by the stage coach and canal proprietors, and they, together with other interested parties, to say nothing of the large class of people who objected to innovations on general principles, made the work of the first railway mechanical engineers one of extraordinary difficulty. It was not an uncommon thing for the engine men to be pelted with stones and brickbats when on a journey, and George Stephenson himself was in danger of his life on more than one occasion. Logs of wood, etc., were frequently placed on the track in front of an approaching train, which was quite serious, as, in those days of insufficient brake power and cumbersome reversing gear, it was almost impossible to stop the engine in time. Even some of the civil engineers of that day were unfavorable to locomotives, as, in their opinion, the lines could be worked more cheaply and better by horses. With a few brilliant exceptions, the English landed gentry were opposed to Stephenson and his infernal machines, a certain nobleman, in the course of a public speech, declaring that he "would rather meet a highwayman on the road than an engineer." The absurd and exasperating questions put to Stephenson by Parliamentary lawyers when early railway bills were introduced are matters of history.

We will now recross the Atlantic and see what the Americans were doing about this time. In sharp contrast to the general opposition which the indomitable Stephenson and the handful of enterprising merchants and capitalists who supported him had to fight against, it is refreshing to read that, as Mr. Charles Francis Adams has expressed it,† "All through the time during which Stephenson was fighting the battle of the locomotive, America, as if in anticipation of his victory, was building railroads. . . . The country, therefore, was not only ripe to accept the results of the Rainhill contest, but it was anticipating them with eager hope." On the fourth of July, 1828, the construction of the Baltimore and Ohio Railroad was begun, the first act being performed by the venerable Charles Carroll, of Carrollton, the only then surviving signer of the Declaration of Independence. At the close of the ceremony of breaking ground Mr. Carroll said, "I consider this among the most important acts of my life, second only to that of signing the Declaration of Independence, if even second to that."

The American mechanics were also following closely on the heels of their English brothers, and in 1830 the South Carolina Railroad Company contracted with Mr. E. L. Miller to build a locomotive which was named the Best Friend. It was the first locomotive ever built in America for actual service upon a railroad, and was designed by Adam Hall and constructed by the West Point Foundry Association, foot of Beach Street, New York City. It was a four coupled, inside connected engine, as shown in Fig. 4, which is reproduced from a copy of the original drawing. The cylinders were 6 inches in diameter by 16 inches stroke, driving wheels 4 feet 9 inches diameter, weight 4½ tons. The boiler was vertical, and was totally destroyed by explosion on June 7, 1831, being, it is said, the first locomotive boiler explosion on record.

The second locomotive built for actual service in the United States was the West Point, in 1830-31; it was built for the same railroad and at the same shops as the Best Friend. This engine had a horizontal tubular boiler with tubes 2½ inches in diameter and 6 feet long. Four coupled driving wheels 4 feet 9 inches diameter. Inside connected cylinders 6 inches diameter by 16 inches stroke. With 5 cars containing 117 passengers this engine made 2½ miles in 8 minutes.

The third American engine built for actual service was the De Witt Clinton. This engine was also constructed at the West Point Foundry in 1831, and was made for the Mohawk and Hudson Railroad, now a part of the New York Central and Hudson River Railroad, to the order of Mr. John B. Jervis, chief engineer of the former road. A full size model of this engine was exhibited at the Columbian Exposition, 1893, and is illustrated on the right hand side of Fig. 5. The engine on the opposite side of the cut is No. 999, and will be described in its proper place later on. The outward appearance of De Witt Clinton was very similar to America, Fig. 2, but the cylinders were inside connected and the frames were of wood, reinforced with iron. We also notice that it had a rudimentary smoke box. The boiler had 30 copper tubes, 2½ inches diameter, wheels 4 feet 6 inches diameter, cylinders 5½ inches diameter by 16 inches stroke, weight of engine and tender about 6 tons.

The first regular trip was made between Albany and Schenectady, August 9, 1831, when, with a load of three coaches, a maximum speed of 15 miles an hour was attained, but, alone, the engine was run at a speed of 40 miles an hour. The conductor had a small seat on the rear of the tender and gave the signal for starting by blowing a tin horn. We are told that "the fuel used was dry pitch pine, and as there was no spark arrester on the stack, the sparks poured back on the passengers in such a volume that they raised their umbrellas as shields. The covers were soon burned off these, and each man whipped his neighbor's clothes to put out the fire started by the hot cinders."

The illustration shows the engine with a large steam dome, but in an official drawing published in the Railroad Gazette of May 25, 1883 (which also contains authentic drawings of the Best Friend and West Point), the engine is without a steam dome. The New York Central and Hudson River Railroad Company's description gives the diameter of driving wheels as 4 feet 6 inches, but the wheels on the above named drawing scale 5 feet. There are other discrepancies, but, nevertheless, Fig. 5 may be accepted as a fair representation of the De Witt Clinton.

Mention having been made of the conductor blowing a tin horn, we note, by the way, that an old print showing Stephenson's Planet on Liverpool and Manchester Railway, year 1830, represents the engine driver blowing a bugle after the manner of a stage coach guard. The first whistle was a steam trumpet placed by George Stephenson on the Samson, a freight engine for the Leicester and Swannington Railway, in May, 1833.

(To be continued.)

* This engine was illustrated in the SCIENTIFIC AMERICAN SUPPLEMENT, April 7, 1894.

† See "Railroads: Their Origin and Problems."

M. Posniloff, the manager of the steel department of the Obouchoff Steel Works, St. Petersburg, has devised a simple method of preventing the steel from splashing, when being run from a ladle at a considerable height. A tube is prepared of thin sheet iron, such as is used for roofing. The tube is 24 in. inside diameter, and is suspended from an iron ring, to which there are riveted three bars on the surface of the mould just before casting. The steel is poured from the bottom of the ladle into the middle of the iron tube. All the splashes are thrown on the walls of the tube, which gradually melts away during the rise of the surface of the liquid steel in the mould.

THE RENO RAPID TRANSIT PLAN FOR BROADWAY, NEW YORK.

By J. W. RENO, E.M., New York City.

IT is a matter of recent history that the plan for an underground railway along Broadway, estimated to cost $50,000,000, has failed to obtain the sanction of the proper authorities. It is the purpose of this article to show that an economical rapid transit system may be constructed along that thoroughfare, which will offer equal facilities to the public and will save in cost of construction about $20,000,000, as compared with the scheme which has failed.

The essential features of this, the so-called Reno plan, consist of a method of construction of a four track tunnel under Broadway, by which no property rights will be invaded and the traffic and business of the street but slightly interfered with during the prosecution of the work. In addition, ample provision is made in this plan for the disposal of the pipes, electric subways and sewers, so that the street surface need not be again disturbed for years to come.

The opposition of the property owners to the commission's plan arose primarily from three causes:

1st. The necessary condemnation of the sidewalk vaults.

2d. The necessity for underpinning numerous foundations, on account of the tunnel excavation in close proximity to them.

3d. The serious loss to business during the necessary "shoring up" of the building fronts and the consequent interruption of the sidewalk and street traffic.

Expert testimony, under oath, before the Coudert commission, was produced to show that the first of these items would add from $12,000,000 to $16,000,000 to the cost of the tunnel from City Hall to Thirty-fourth Street; that the second would add $3,500,000 more to the cost; while the third item it was impossible to estimate correctly upon.

In the plan here proposed these contingencies, amounting to about $19,500,000, will be eliminated. And, furthermore, only a portion of the $2,500,000 allowed in the commission's plan to replace the present pipe and wire systems under Broadway will be necessary, since in the Reno plan most of these structures need only be shifted a few feet in order to place them in their proper position in the pipe galleries.

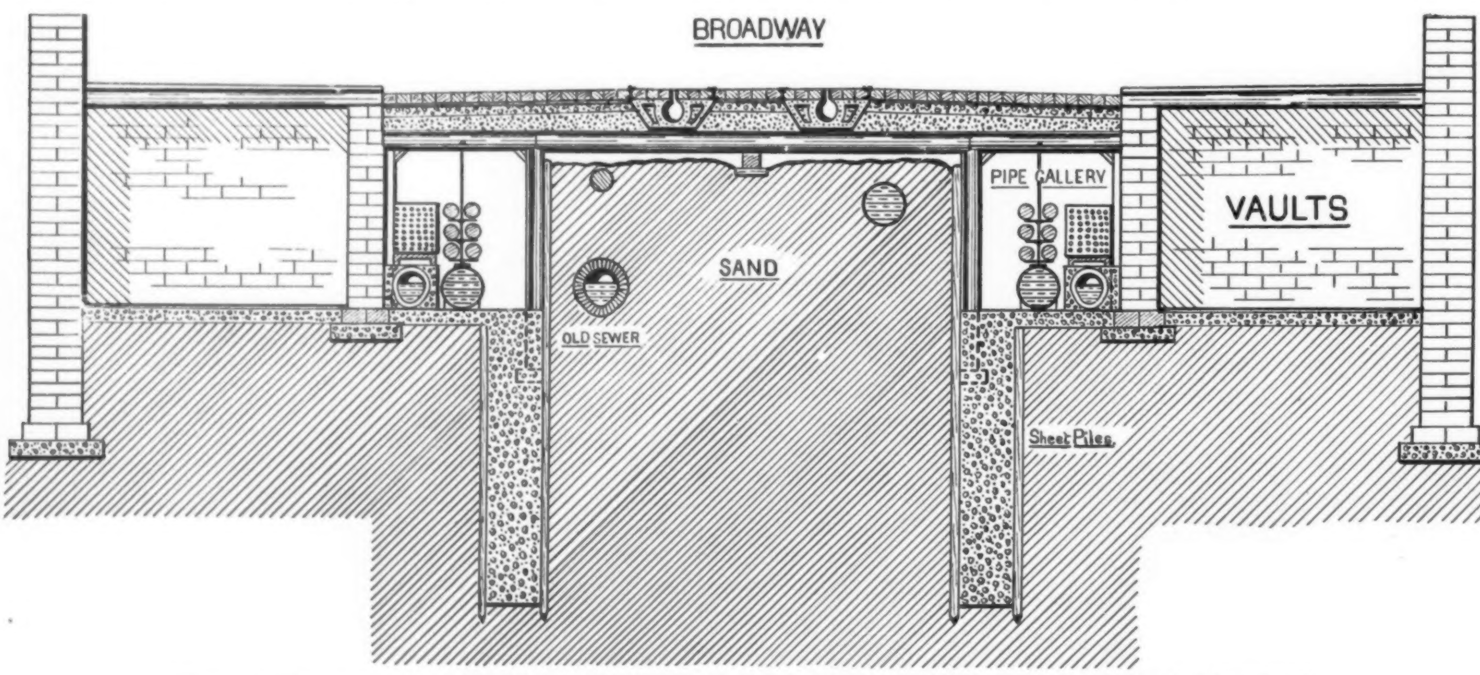


FIG. 1.—METHOD OF CONSTRUCTING THE PROPOSED RENO TUNNEL BENEATH BROADWAY, NEW YORK.

The method of construction of this tunnel (see Fig. 1) will consist in sinking a narrow trench between rows of previously driven special sheet piles and then constructing the concrete and steel sidewall in this trench, as shown. These sidewalls and the adjoining pipe galleries will be completed on one side of the street at a time, for a block in length. The tunnel roof beams can then be inserted longitudinally between the cable road tracks and swung around transversely into place, one under each of the cable "yokes," and the roof thus completed. This construction will leave the "core" of ground within the tunnel undisturbed until the walls and roof are completed, and its removal can then be cheaply effected by hauling it out in train loads to the end of the tunnel—a very economical method of excavation and one which will be absolutely safe against possibility of damage to the adjacent buildings. On removal of the tunnel "core," it becomes a simple matter to lay the concrete floor and to erect the internal columns and girders, thus completing the tunnel, as shown in Fig. 2. By reference to the perspective (Fig. 3) of the stations it will be seen that even at these points the sidewalk vaults will not be encroached upon. The ticket and waiting rooms are located under the cross streets, and the stairways leading to them, only 12 feet in height, will be carried down adjacent to the building walls. The space under the platforms is available for the pipes from the pipe galleries, in which position they can be easily reached for repairs.

North of Union Square the system has two tracks under Broadway and the Boulevard, with stations, as proposed, at Twenty-third, Thirty-fourth, Forty-second, Fifty-ninth Streets, etc. From Forty-second Street northward an easy transfer (by traffic agreement) can be made, as shown in Fig. 4, to the surface cars. With express stations about one mile apart on the Boulevard, a high speed (thirty miles per hour) will be practicable. These surface cars would always be close at hand to transfer passengers, without additional fare, to within

one block of their destination. Of course, this scheme contemplates mechanical traction for the Boulevard surface line, with large cars capable of a speed of twelve miles per hour.

These cars, in conjunction with the underground express trains, will furnish ideal rapid transit facilities to residents of the west side. As the Boulevard surface cars turn from Broadway into Forty-second Street and continue to the Grand Central station, they will furnish a valuable communication between the east side and west side rapid transit traffic at this point.

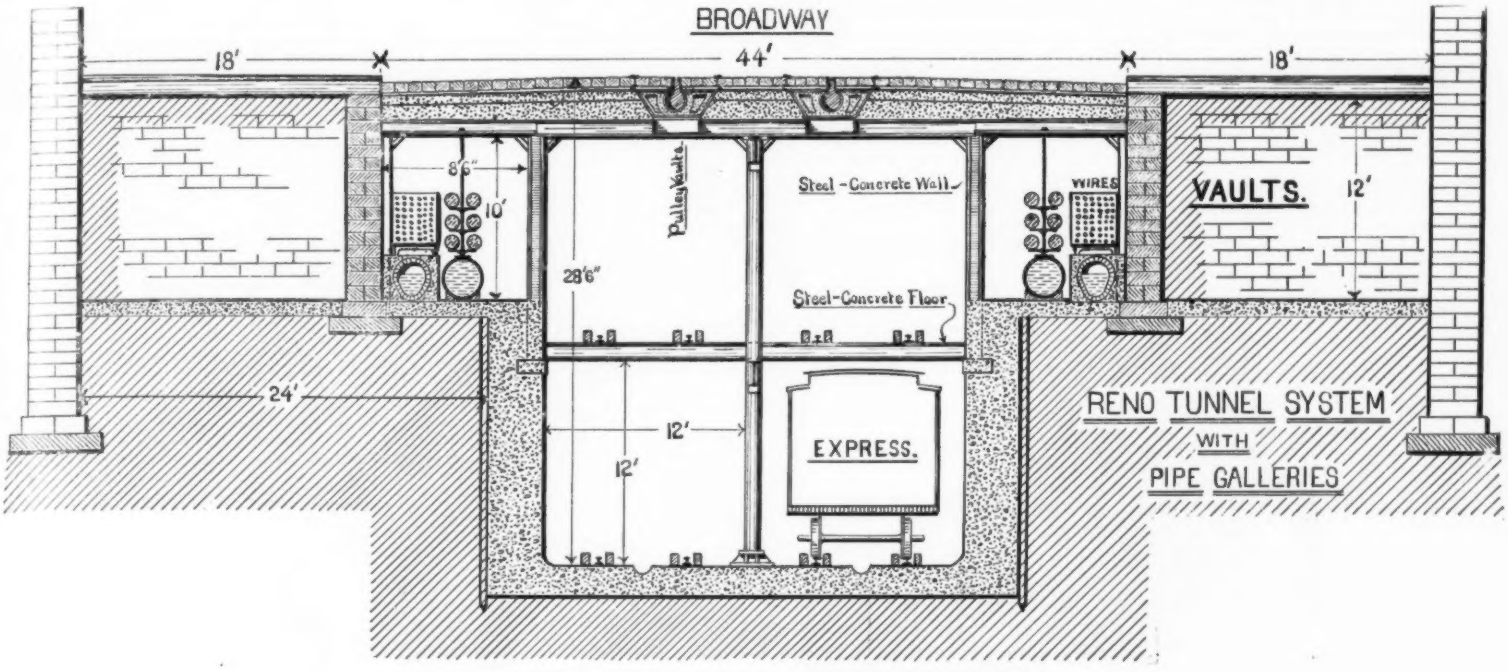


Fig. 2.—THE RENO TUNNEL COMPLETED.

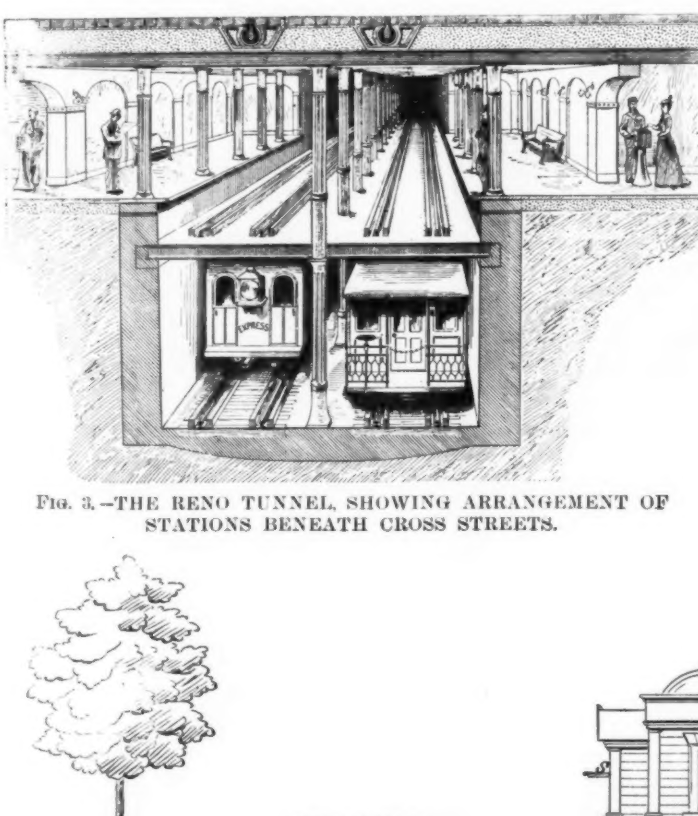


Fig. 3.—THE RENO TUNNEL, SHOWING ARRANGEMENT OF STATIONS BENEATH CROSS STREETS.

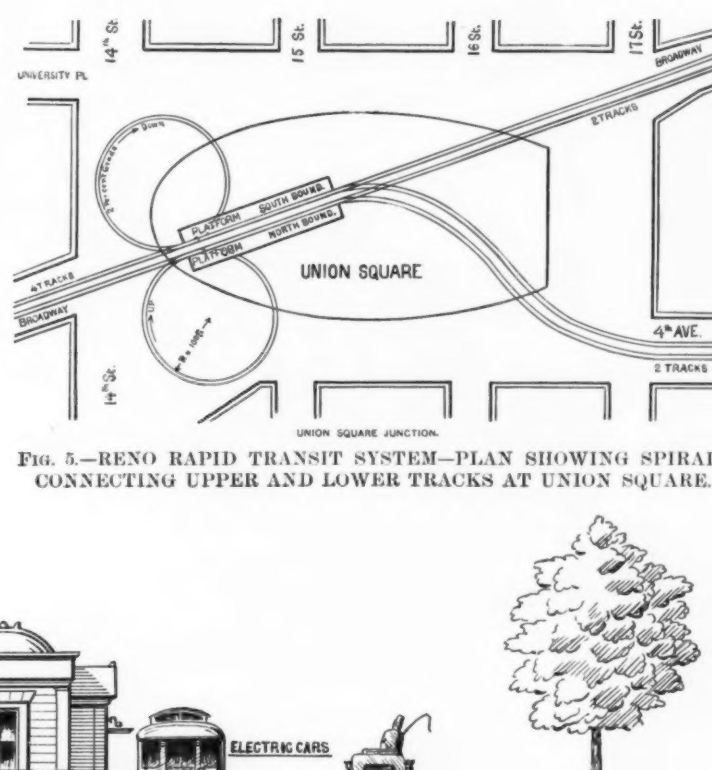


Fig. 5.—RENO RAPID TRANSIT SYSTEM—PLAN SHOWING SPIRALS CONNECTING UPPER AND LOWER TRACKS AT UNION SQUARE.

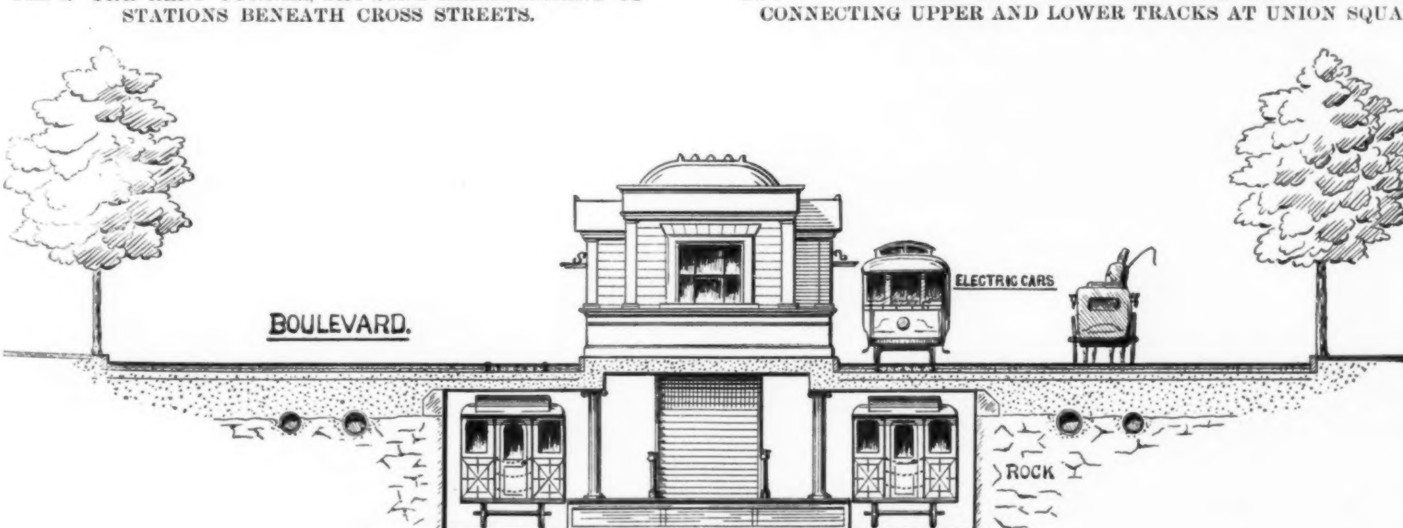


Fig. 4.—SHOWING CONSTRUCTION OF TUNNEL BENEATH THE BOULEVARD AND METHOD OF TRANSFER TO SURFACE CARS.

The east side system will branch from the main line at Union Square and continue with two tracks under Fourth Avenue to One Hundredth Street, thence westerly under that street and northerly under Central Park to Lenox Avenue and thence to the Harlem River. This line will give adequate and direct rapid transit facilities to the more or less densely populated sections of the city east and north of the park.

It will be noted that since the tracks of both the east and west side systems come together into four tracks below Union Square, the whole system will be a well balanced one, and no congestion of traffic can occur. The Union Square junction is so designed that the station platforms, common to all trains, will be only twelve feet below the surface (see Union Square plan).

The operation of the system at this point may be described as follows: North of Union Square the west side trains will have as local tracks the proposed Boulevard electric cars, thus practically supplying four tracks from One Hundred and Thirty-fifth Street to Forty-second Street. From this point, with stations only half a mile apart, viz., Forty-second, Thirty-third, Twenty-third, and Fourteenth Streets, no local transfers will be necessary. On reaching the Union Square station, the local trains will continue upon the upper tracks to City Hall, distributing their passengers at stations about five blocks apart. The express trains, in order to reach the lower tracks of the double-decked tunnel, will take the right-hand spiral as shown, which, with a descending two per cent. grade, will accelerate the start of the train toward City Hall. In like manner the express trains going northward will be slowed up on reaching the two per cent. up grade on the corresponding spiral for that track. It will be seen that in this design the station entrance and exit will be near Fourteenth Street, while the spiral tracks will furnish the very desirable gravity system for rapidly starting and stopping the trains.

The design of the double-deck tunnel lends itself perfectly to the proposed loop of the local tracks around City Hall Park to the Bridge station, while the express trains, with an ascending grade of two per cent., would land their passengers at the stations south of Ann Street, at platforms only twelve feet from the surface. From Ann Street, storage tracks under Park Row, as proposed, would connect the local and express systems. It will be seen from the above that the fancied objection to the double-deck tunnel, because of the increased depth to the lower tracks, does not exist, because no station platforms need be more than twelve feet below the surface. This is only one-half the distance to the average elevated road station.

In regard to the possibility of noise in the double

deck tunnel, it should not exceed the dull rumbling now produced by the Brooklyn Bridge trains as they roll into the terminals. This may be easily verified.

In other words, if the Reno plan has no disadvantages compared with the commission's former plan as regards convenience of operation, and in construction can show a saving in cost of about $20,000,000, there is no doubt that a responsible construction company can be found to undertake the work upon this plan along the Broadway route. Furthermore, as many property owners testified before the Coudert commission that they would favor a Broadway tunnel, were it free from the disadvantages of the commission's plan, their consent to the construction of the Reno plan is almost assured.

In comparing the accessibility and earning power of this Broadway tunnel with that lately proposed for Elm Street and Fourth Avenue, it is well to remember that a tunnel on the latter route will land its passengers about half a mile distant from the entire theater and shopping districts along Broadway and Sixth Avenue.

The Elm Street route proposes a half mile detour along Forty-second Street, and again a mile detour at One Hundred and Fourth Street, which will be a great hardship to patrons of the line north of Central Park. The plan here described, being along direct and central routes, will avoid these detours, and will give ample rapid transit to both sides of the city at a cost well within the $35,000,000 limit fixed by the courts.

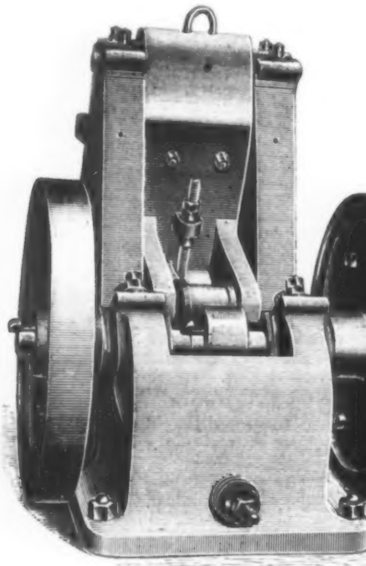


Fig. 1.

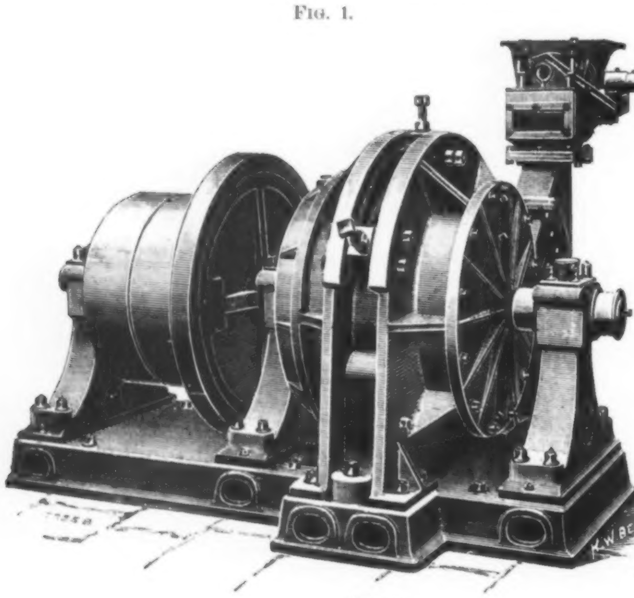


Fig. 2.

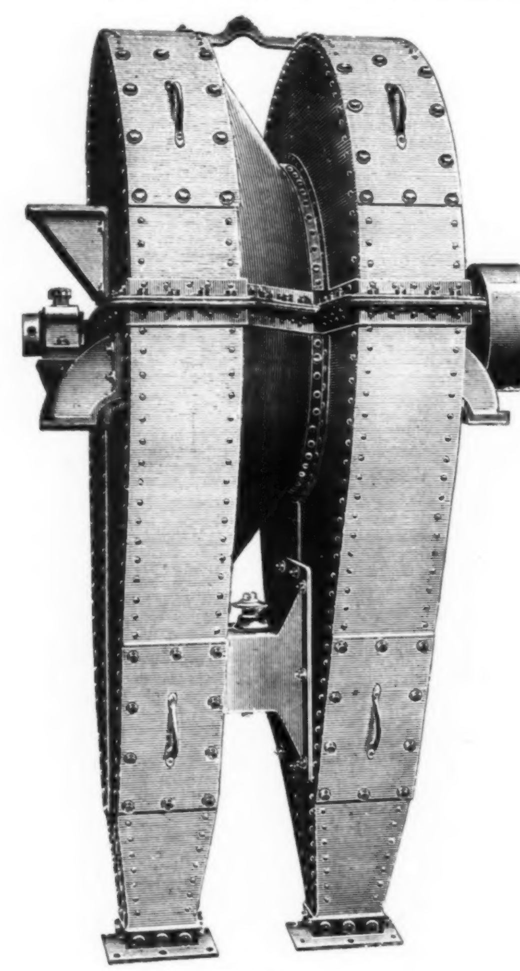


Fig. 3.

CRUSHING, GRINDING, AND SEPARATING MACHINERY

CRUSHING, GRINDING AND SEPARATING MACHINERY.

We illustrate herewith some machines for crushing, grinding and separating materials that have been made by Messrs. William Johnson & Sons, of Castleton Foundry, Armley, Leeds. Fig. 1 gives a perspective view taken from a photograph of what is known as the "Dragon" ore and stone crusher, which is made under Johnson & Walker's patents. The machine generally resembles the Blake crusher in principle, but has certain improvements in detail. The jaws are on the Blake principle, but in place of the toggle arrangement there is fitted an eccentric disk on a shaft, as can be seen by the engraving, Fig. 1. The eccentric, in turning, imparts a reciprocating motion to the swinging jaw by pressing against an antifriction roller, which in turn is mounted on an extension of the casting which forms the swinging jaw. This jaw pivots on trunnions at the top, and, as it swings toward the fixed jaw, crushes the material which is fed down between the two.

The size of the cubes of crushed material produced by the machine is controlled by moving the swinging jaw backward or forward bodily. This is effected by means of a vertical wedge, which, through the action of a nut and screw, alters the locus of the swing as it is raised or lowered. The swinging jaw is moved forward by the eccentric, but swings back by its own weight. There is, however, a spring which assists the backward movement, and is necessary when the machine is working quickly. The advantages claimed for the "Dragon" crusher as compared to the older machines are that it has fewer wearing parts and requires less power to drive it, as the action of driving is more direct. The eccentric disk from which the movement is obtained is easily renewable, as are also the bearings in which the journals of the antifriction roller turn. The crushing jaws, jaw check plates, antifriction roller and renewable eccentric are made from what is known as "Dragon" steel. This is a special alloy which is adopted for these purposes, being exceedingly hard, so that it cannot be machined, and will not soften, yet is very tough, so that it will bend considerably before breaking. The bearings of the eccentric shaft are of gun metal, while the trunnions for the swing jaw and the eccentric shaft are of Bessemer steel. Another design of machine combining the same general principles is made for fine crushing. In this the trunnions are at the bottom of the jaw instead of at the top.

The next machine we illustrate is a "Dragon" grinding mill which has a new arrangement of shaft fittings designed on a principle patented by Messrs. Johnson & Walker. This machine we illustrate in Fig. 2. This mill is on the centrifugal principle. It consists of a stout casing, as shown, having an axial shaft driven by belt gearing, the pulleys for which are shown. The crushing rollers are carried between two drivers. These have open ended slots in them, and in these slots the axial bearings of the rollers fit. When the shaft is caused rapidly to revolve, the rollers are naturally carried round by the drivers, and, by centrifugal force, are caused to press against the inside circumference of the casing, which thus forms a roller path.

The centrifugal principle of grinding is, of course, not new, but it has always been attended by some trouble in application, owing to the rapid wearing of the parts and the difficulty of their renewal. The stresses set up are, as may be easily imagined, severe, and in order to fix the shaft fittings firmly in place, they have been forced on to square parts of the shaft by hydraulic pressure and are further secured by keys. This rendered it necessary to return the whole shaft and fittings to the manufacturers when the fittings required renewal through becoming worn, as they speedily did when grinding some materials. To overcome this, the parts most subject to wear were made separately, so that they could be fitted on; but this was attended by a drawback, as the joining faces between the permanent and renewable parts had to be machined. In the mill now under notice, however, the drivers and propellers are easily taken off and replaced, and yet are quite rigidly attached to the shaft.

These mills are used for grinding cements, lime, phosphate rocks, basic slag, marls and other minerals, colors, ginger, rice and other produce, chemicals and other materials of a like nature. The feeding inlet is arranged to supply the material direct to the feeding propeller.

Our next illustration, Fig. 3, gives an exterior view of the "Dragon" separator designed on a principle patented by Messrs. Johnson & Walker which may be used in connection with the grinding mill last described, or any other system of grinding, or for the purpose of grading any powders to required fineness. As will be seen, the apparatus consists of two parts or chambers, which are composed of light steel plating. The separator is intended to supply the place of sieves or large stive rooms working with exhaust fans. It is carried by cross timbers in the roof or upper floor of a building, so that the floor space below is quite clear. The two chambers are connected by a cone, and also by a short length of pipe. There is a horizontal shaft running in bearings on the outside of the casings and driven by a belt and pulley. On this shaft there are a disintegrating spreader for distributing the material, an air propeller or fan, and baffle or beating plates. There is a hopper, as shown, through which the powder to be acted upon is fed into the machine, and the outlet nozzles from which the separated material escapes are at the lower end of each chamber.

The action of this machine is as follows: The powder, when fed through the hopper, falls on to the disintegrating spreader, and is thus thrown in a shower into the first or tailing chamber. The fan is in the second chamber, and is so arranged as to set up a current of air from the first to the second chamber. The finer particles of the powder, offering more surface to the current in proportion to their weight, are carried into the second chamber, where they fall to the bottom and are discharged through the outlet nozzle. On the other hand, the larger particles or tailings are not acted upon by the air current to the same extent, and fall to the bottom of the first chamber to be discharged through the nozzle. To aid the separating action there are baffle plates stretched across the opening between the two chambers. These take the form of inclined planes or louvers. The larger particles strike on these if they are being carried through, and, losing their momentum, fall to the bottom of the first chamber.

The degree of separation effected naturally depends on the strength of the air current, and this is adjusted, not by altering the speed of the fan, but by regulating the lower opening or pipe already referred to. This opening, through which a return air current passes, performs another function. As the tailings drop down in the first chamber, they may be accompanied by some of the finer particles. The return current, passing from the fine chamber to the tailings chamber, ascends against this falling stream of material, and any fine particles coming down are carried back and pass into the fine chamber. A damper is placed in the pipe to regulate the size of the opening and thus modify the current.

The advantages claimed for this machine are the sav-

ing in space and expense as compared to the old stive rooms. It has an advantage over sieves in a comparative absence of wear and tear, which is very marked with the latter, especially when the material is gritty or cutting. The wearing of the mesh of a sieve also alters the degree of separation. When scrapers or brushes are used with sieves, they are often rapidly spoiled. The separator is used for the same descriptions of materials as are dealt with by the grinding mill described.

We are indebted to London Engineering for the cuts and particulars.

THE FILTZ ROTARY STEAM MOTOR.

ROTARY motors present great advantages over alternating ones. They have no dead center, require no flywheel and begin operation immediately. Their revolution occasions no jarring, and light foundations therefore suffice for them.

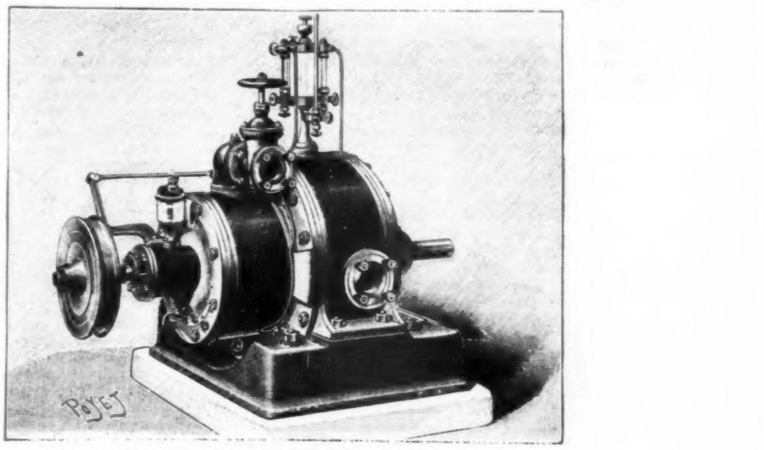


FIG. 1.—THE FILTZ ROTARY MOTOR.

Up to the present, steam turbines have been especially constructed. It will suffice to mention the Parson turbo-motor, used in the navy, and the Laval turbine.

Some years ago, the Messrs. Filtz invented a rotary steam expansion motor, a description of which has already been given in this journal. As this engine has recently undergone an entire transformation, it appears to us of interest, by reason of the advantage possessed by motors of this kind, to call attention to the new model. In this motor the steam acts through its pressure, and even expands for a certain period. The motor is capable of running at different velocities and of changing direction, and this permits of adopting it not only for actuating centrifugal pumps and dynamos, but also for the propulsion of carriages and boats. It is adapted, moreover, for industrial purposes, since engines of this system are constructed of from 2 to 100 horse power. Fig. 1 gives a general view of it.

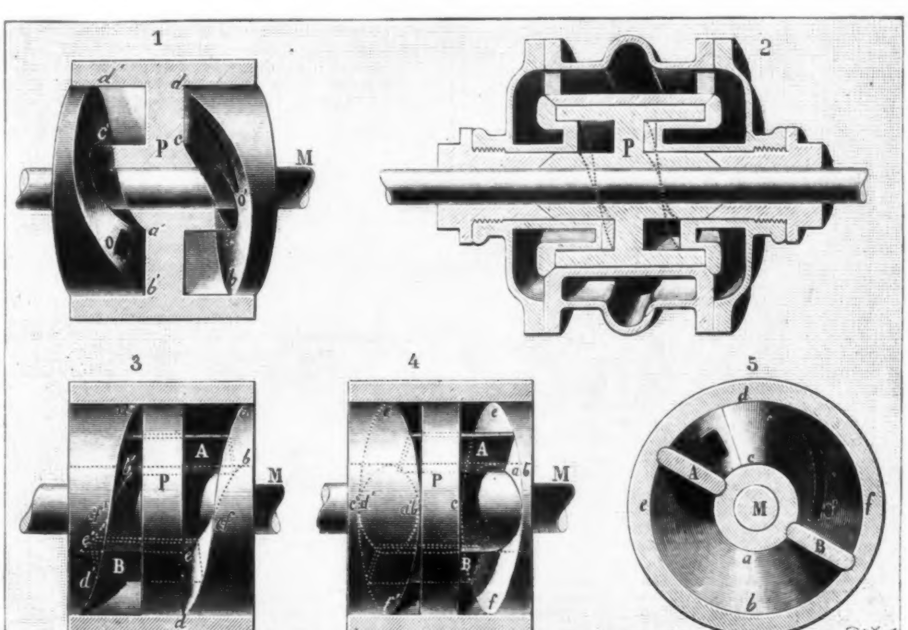


FIG. 2.—DETAILS OF THE VARIOUS PARTS OF THE MOTOR.

In principle, the shaft, M, of the motor receives its rotary motion from a plate, P (Fig. 2, Nos. 3 and 4), carrying two wings, A and B, which are diametrically opposite and upon which the steam directly acts. These wings, A and B, which form a piston, traverse by slight friction the plate, P, through two slots formed for the purpose. In the rotary motion of the plate, P, they take on, with respect to the latter, an alternating motion under the influence of two helicoidal pieces that guide them.

Let us now enter into the details of construction of the motor, the principle of which we have just briefly made known. Nos. 3 and 4 of Fig. 2 give, diagrammatically, views of the interior of the apparatus, while No. 5 gives a horizontal section made according to the lower plane of the plate, P.

A hollow cylinder, seen in section in the figures, is closed by two bottoms, f and f', having helicoidal faces and revolving one to the right and the other to the left, and uniting according to two generatrices, one of them, a b, below, and the other, c d, above. These bottoms are traversed, through stuffing boxes, by the driving shaft, M, which carries the plate, P. This latter rests by slight friction upon the lower generatrix, a' b', of the bottom, f', and upon the upper generatrix, c d, of f. The plate, P, thus divides the hollow cylinder into two parts in the direction of its length. A special arrangement assures the tightness along the generatrices upon which the plate, P, rests. It will be seen from No. 2 of Fig. 2 that the section of P has in reality the form of a double T. Such form is necessary in order that the steam may not pass from one face of P to the other. The plate, P, which is not capable of moving longitudinally, being held by f and f', receives a rotary motion around its axis. As we have already said, it is provided with two slots into which enter the two wings, A and B, that have for height the spacing of the pieces, d d', and for width the distance, c d. These wings necessarily rest upon the directing helicoidal faces. On another hand, their vertical edges rub, one of them, against the shaft, and the other against the internal surface of the cylinder. They, therefore, form steamtight partitions. A particular packing permits of preserving the tightness despite the wear, and of taking up the play produced. The space on each side of the plate, P, is thus divided by the lines of contact, a' b' and c d, and the two wings, A and B, into three parts.

The steam ports, o and o' (No. 5), debouch on each side of the contact parts, a' b' and c d. Immediately after the line of division (in the direction of the motion) is the admission port, o, which is very short, and on the other side is the exhaust port, o', which is much elongated. The admission and eduction of the steam are regulated directly, without any distributing part, through the passage of the wings in front of the ports. The steam acts upon the wings, thrusts them, and thus forces them to slide upon the helicoidal bottoms in carrying along P, and, consequently, the shaft, in their rotary motion solely. In order to understand the operation of the apparatus, it suffices to consider what takes place on one of the sides of the plate, P, the apparatus being symmetrical with respect to the latter. Let us consider the lower part, for example (No. 5).

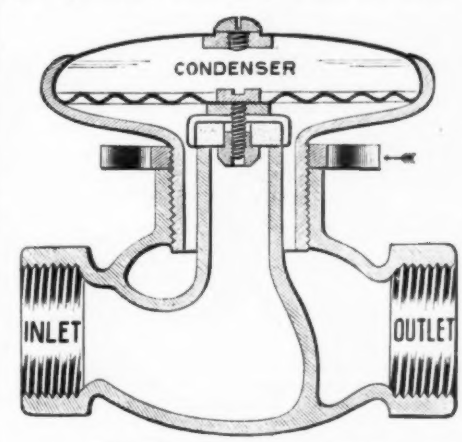
As soon as the wing, A, has uncovered the admission port, o, the steam acts upon it with full pressure. The steam imprisoned between A and B expands and acts upon both of the wings. But, since the effective surface of A upon this side of the plate, P, is not so wide as that of B (as may be easily seen in Nos. 3 and 4), the action upon B prevails over it. In the third case, between B and the line of division, c d, of P, the steam escapes through the eduction port, o'. This port should be formed on the line, e f, according to which the surfaces of A and B become equal, for, if such an arrangement were not made, the steam would act by counter-pressure. After B has exceeded e f, the live steam alone tends to make the shaft revolve.

According to a mathematical theory established by Mr. R. Guyot-Sionnest, civil engineer of naval constructions, the motive power varies from simple to double, and the expansion is equal to ⅔. This feeble expansion corresponds to a middling utilization of the steam; so Mr. Filtz has been led to construct upon the same principle motors with multiple expansion, having their plates, P, mounted upon the same shaft. The bottoms of the cylinders are then free, and this realizes the couple motor. Quite a large number of motors of this new system have been constructed and are now in service. We may mention in particular a 70 horse power engine capable of developing 100 horse power. Some of the motors have a change of direction, but the steam acts quite poorly under such conditions, on account of the form of the exhaust port, which becomes an admission one, and on account of the compression that results therefrom. This inconvenience is of slight importance in the application of the Filtz motor to carriages and boats, since running backward is done only occasionally.

In conclusion, we shall give a few data as to the motors constructed. One of 3 horse power, with single cylinder, weighing 60 pounds, develops such power at 1,200 revolutions a minute, for a diameter of 3¼ inches, the pressure of admission being 13 pounds. For the same pressure, a compound motor, the cylinders of which have the respective diameters of 14 and 24 inches, gives 40 horse power at 300 revolutions per minute. It weighs 2,640 pounds and takes a space of less than 35 cubic feet. The consumption may descend to 18 or 20 pounds per horse hour in a compound engine running by condensation.—La Nature.

THE MIDGET STEAM TRAP.

THERE are not many steam traps on the market, says Engineer, which can compare with that shown in the accompanying engraving, in point of size and fewness of parts.



THE MIDGET STEAM TRAP.

This is an automatic device for use with steam pressure, and is made up essentially of three parts—the body, the sealed diaphragm and valve, and the lock nut. The working of the trap depends upon the action of the corrugated metallic diaphragm or piston, called the condenser, which is charged with a volatile fluid, and hermetically sealed. The variations of temperature in the trap brought about by the presence of water and steam intermittently cause the diaphragm to rise or fall, thus opening or closing the valve. To adjust the trap the condenser is turned to the left, allowing the water of condensation to pass the valve. As the water increases in temperature, the contents of the sealed chamber volatilize and cause the corrugated flexible diaphragm to expand. When steam commences to blow through, the valve ought to close automatically, and in this position should be locked by the lock nut shown. It may then be left to work automatically. Now, the cool atmosphere acting upon the thin dome of the condenser causes the condensation of the vapor contained therein, and creates a partial vacuum, the tendency of which is to pull the valve from its seat, and, as the inventor puts it, "feel for steam." It will be seen, therefore, that the presence of steam below the valve is essential to keep it closed, and as soon as this is wanting the valve opens automatically and allows any water to escape. The trap is noteworthy for its compactness and neatness, there being no frictional contact, and consequently no likelihood of jamming; while, being made of gun metal, there is nothing to corrode. The makers of the trap are Messrs. James Armstrong & Company (Limited), 116 Queen Victoria Street, London.

VULCANITE GRAPHITE BEARINGS.

ONE of the novelties in the Altoona shops of the Pennsylvania Railroad (says the American Engineer and Railroad Journal) is the use of vulcanized graphite in the bearings of connecting rods and in engine truck boxes. The material is substantially what is known as vulcanized fiber impregnated with powdered graphite or plumbago. In applying it to bearings, a groove is planed in the brass longitudinally to the journal. Thus in the bearings for a journal 5¼ in. diameter, two grooves, each 1 in. wide and ⅝ in. deep, were slotted transversely in the bearing and longitudinally to the axis of the journal. These are made slightly dovetailed, so as to hold the fiber in position. It is made in sheets ½ in. thick, and it is found that it wears better if the pieces put into the journal are placed so that the wear will come endwise to the material, or on its edge as it is made. Two thicknesses of it are therefore drawn into

each groove from its end. The report is that it wears much better than babbitt, and is in every way more satisfactory.

DELIBERATE DECEPTION IN ANCIENT BUILDINGS.*

EVER since Mr. Penrose made public his measurements establishing the existence of deliberately constructed curves in the lines of the Parthenon, attention has been consistently directed to the subject, and his theory has been generally accepted that they were refinements introduced in order to discount certain optical illusions. Deflections from the vertical, vertical curves, and curves in horizontal lines were discovered; these last lying in vertical planes, so that no plan deflections were found. Extremely delicate, these refinements have been considered to have existed only in Greece, and to have had no analogy, even of a crude description, in other than Grecian buildings.

Though Mr. Penrose established the existence of these curves, they had already been discovered some few years earlier by Mr. Pennethorne in 1837, also by Messrs. Hoffer and Schaubert, who published the discovery in 1838 in the Weiner Bauzeitung; nor, in the case of Mr. Pennethorne at least, had this discovery been accidental. In 1833 he had visited Egypt, and there he had found, at the temple of Medinet Habou, that the cornices of the inner court formed curves on plan, concave to a spectator standing within the inclosure. Subsequently he had been struck by the passage in Vitruvius referring to the construction of curves, and had consequently revisited Athens and discovered the curves of the Parthenon. He appears to have taken little trouble to make his discoveries known, and so far as the curves at Medinet Habou were concerned, made no announcement till 1878, and even at the present time their existence is scarcely recognized.

It was in this position that the matter rested until quite recently, with the solitary exception of the announcement by Jacob Burckhardt of the discovery of convex plan curves in the flanks of the great Temple of Neptune at Pæstum, and this has been regarded as something quite exceptional.

In June, 1895, however, a notable article appeared in the Architectural Record, of New York, by Prof. W. H. Goodyear, containing announcements of discoveries of a character and completeness of sequence which even he seems scarcely to comprehend, and which look much like revolutionizing the whole theory as to the intention of curved lines in ancient buildings; and that article has been followed by others yet more recently, drawing attention to the existence of plan variations of an analogous character in mediæval Italian buildings, and sufficiently startling in the conclusions to which they inevitably tend to cause them to be received almost with incredulity.

His first discovery was that the courts at Karnac, Luxor, and Edfou all exhibited plan curves similar to those at Medinet Habou, but he appears to have seen no more in this than confirmation of Pennethorne's observations. On the other hand, the date sequence is all-important, for while Karnac and Luxor are, like Medinet Habou, of the Theban period, though somewhat earlier, dating, possibly, in the earliest example to 1500 B. C., the temple at Edfou is Ptolemaic, belonging to the renaissance of Egyptian architecture, and cannot be earlier than 250 B. C. (this being extreme). Consequently it was built long subsequently to the temple at Pæstum.

Carrying on the sequence, too, Prof. Goodyear found plan curves, similar to those at Pæstum, in the cornice line of the well-known Roman building, the Maison Carrée at Nîmes, and thus established the existence of a series of cognate phenomena in all periods of ancient architecture of which we have complete examples left.

His theory, a revival of that of Hoffer with regard to the Parthenon, but one which has not hitherto been much considered in England, is that these curves were intended to deceive—to convey to a spectator within the courtyards of Egypt, or without the temples at Pæstum and Nîmes, an impression of greater length than that which actually existed, by means of an intentionally exaggerated perspective; and he points out that the Parthenon curves in vertical planes have the same tendency, whatever other explanation of them may also be possible, and in a more refined and delicate manner than have the horizontal curves.

Had Prof. Goodyear's discoveries stopped here, therefore, they would have been highly significant; but they have recently been carried much further during his survey of Italian buildings, undertaken by him for the Brooklyn Institute. For example, he finds similar convex curves internally at Fiesole, Genoa, Trani, and in San Apolinare Nuovo, Ravenna; and he gives, in his article in the Architectural Record, a photograph of the curve at Trani, along the cornice above the nave arcade, which would be convincing enough had not the half-tone block been evidently "doctored." Doubtless the effect is that shown, but a carefully figured plan would have better established the existence of the curve and its extent. Other instances he quotes as occurring in cloisters, that of the Celestines at Bologna being an exact counterpart, as to the use and place of curve, of the Egyptian courtyards already mentioned. That they were intentional, not accidental nor due to thrusts, he entertains no doubt; and he goes on to say that "these curves degenerate in the later middle ages into bends which may be easily ascribed to careless building, when considered as isolated cases. Such bends are more probably careless constructions of the earlier and more regular curves."

He says no more about these bends, but to any one who is accustomed to taking walks along the triforium galleries of mediæval cathedrals, they must be known, being of not altogether uncommon occurrence, and then evident to a careless observer, and to be found both in England and on the Continent. Still, they are far from universal, and have always hitherto been put down to careless building, or else considered to be the result of thrusts from the aisle vaults, which they do occur; and this view is borne out by their extreme irregularity both in themselves and when compared one with another. There are, for instance, some curious bends in the sill of the triforium in the Angel Choir at Lincoln; but not a trace of anything of a similar nature is to be detected in the nave. Indeed, it is probable that Prof. Goodyear has here demanded too much from his theory, and that a careful survey of the churches in other countries than Italy would go to show that irregularities in triforium lines were the exception rather than the rule, and that where they occur they bear internal evidence of being accidental. So far as the earliest mediæval work of Italy is concerned, in which classic traditions had not been quite abandoned, he may be right; but to attempt to carry his theory further than this, even in Italy in later times, is hazardous without more evidence than has been yet produced.

Abandoning this dangerous ground, he then proceeds to deal with the more common phenomena of a nave narrowing toward the east end of a church, and of one with a deflected choir. Of the former class he found five examples in Italy, and mentions that at Poitiers, being apparently ignorant of the other two known in Northern Europe—Rouen Cathedral nave (slight) and Canterbury Cathedral choir (considerable). The apse of Beauvais Cathedral is also led up to by a slight tendency in the same direction, as is also that of the Collégiale at Huy, in the Ardennes. Strangely enough, the example at Canterbury is generally considered to have been due to a deliberate attempt to obtain illusive perspective—greater apparent length than that which actually exists—thus bearing out Prof. Goodyear's theory.

That the choir deflection, common in England, should be due to the same cause is quite a tenable suggestion, at any rate, more satisfactory than any hitherto put forward. That it symbolizes the leaning to one side of our Saviour's head when he was hanging on the cross—the explanation which is generally accepted—is a mere fanciful idea with no evidence to support it; and even less convincing is the suggestion that all churches exhibiting this axial bend were built in two sections, and oriented by the position of the sun at six o'clock in the morning upon different dates. The theory that it was a deliberate attempt to give, by illusive perspective, an idea of greater length than that which actually exists is supported by the fact that this is undoubtedly the effect produced, especially when viewed from a position slightly to the right or left of the true axis, and when looking from either end of the church. Further, once accepting the possibility of such illusions being intentionally constructed during the Gothic period, it is only reasonable to suppose that they should be employed in England, the home of a distinct and beautiful phase of Gothic architecture, one of the characteristics of which was the great length of the churches. Any known trick which would have the result of exaggerating the appearance of length might, therefore, be reasonably expected to be resorted to.

Two other deflections from uniformity in church interiors which Prof. Goodyear establishes for Italy, and which would have the effect—he claims, the deliberately intended effect—of giving exaggerated apparent length, are that almost invariably the floors rise from entrance to altar in an even slope, and that very frequently the nave arches are of different spans and heights—widest and highest about three bays from the entrance, and decreasing in both respects toward east and west. Modified examples are the Collégiale at Huy, already mentioned, and Peterborough Cathedral.

On the whole, a good case for further investigation seems to have been made out—not in Italy, where Prof. Goodyear appears to have done the work well, but in France and England. Systematic and accurate surveying alone can establish the existence or otherwise of laws governing the deliberate construction of false perspective in Gothic buildings, but such a survey, if undertaken, needs to be very thorough, and would be very costly. G. A. T. MIDDLETON.

* Nineteenth Century.

ROMAN THEATERS.

THE Romans must have become acquainted with the theaters of the Italian Greeks at an early period, whence they erected their own theaters in similar positions upon the sides of hills. This is still clear from the ruins of very ancient theaters at Tusculum and Faesulae. The Romans themselves, however, did not possess a regular stone theater until a very late period, and, although dramatic representations were very popular in earlier times, it appears that a wooden stage was erected when necessary, and was afterward pulled down again, and the plays of Plautus and Terence were performed on such temporary scaffoldings. In the meanwhile many of the neighboring towns of Rome had their stone theaters, as the introduction of Greek customs and manners was less strongly opposed in them than in the city of Rome itself. Wooden theaters, adorned with the most profuse magnificence, were erected at Rome even during the last period of the republic.

The first attempt to build a stone theater was made a short time before the consulship of P. Cornelius Scipio Nasica. It was sanctioned by the censors, and was advancing toward its completion when Scipio, in 155 B. C., persuaded the senate to command the building to be pulled down as injurious to public morality. Respecting the magnificent wooden theater which M. Aemilius Scaurus built in his ædileship, 58 B. C., its scena consisted of three stories, and the lowest of them was made of white marble, the middle one of glass, and the upper one of gilt wood. The cavea contained 80,000 spectators. In 55 B. C. Cn. Pompey built the first stone theater at Rome near the Campus Martius. It was of great beauty, and is said to have been built after the model of that of Mytilene; it contained 40,000 spectators. C. Curio built, in 50 B. C., two magnificent wooden theaters close by one another, which might be changed into one amphitheater. After the time of Pompey, however, other stone theaters were erected, as the Theater of Marcellus, which was built by Augustus and called after his nephew, Marcellus, and that of Balbus, whence Suetonius uses the expression, "Per trina theatra." The construction of a Roman theater resembled, on the whole, that of a Greek one. The principal differences are that the seats of the spectators, which rose in the form of an amphitheater around the orchestra, did not form more than a semicircle, and that the whole of the orchestra likewise formed only a semicircle, the diameter of which formed the front line of the stage.—The Architect (London).

SELECTED FORMULÆ.

Preparation of Artificial Caoutchouc.—An artificial caoutchouc is made according to the following formula given by Mr. Mercier in L'Industrie Textile:

Pure caoutchouc	1,000 grammes.
Pure amianthus with sulphur in proportion	10 to 30 per cent.

5 to 10 per cent. is sufficient for the production of an elastic substance; from 10 to 20 per cent. for a semi-flexible article; and 25 to 65 per cent. for a hard product. The mixture is made with heat in a suitable mixing machine; the caoutchouc cleaned and purified, and the amianthus and sulphur pulverized and sifted. The heating is done preferably inside a cylinder, and it ought to be continued until a perfect mixture is obtained. The dough formed by this mixture is drawn out into sheets or moulded according to requirements. The formula given above is not in sufficient detail to enable the process to be worked.

Liquid Metal Polish.—Levigated rotten stone is the common ingredient of liquid polishes. The following are typical formulæ:

(1.) Rotten stone, levigated .... 2 ounces
Iron subcarbonate .... 6 "
Oil of mirbane, enough to flavor.
Oleic acid, or cotton seed oil, sufficient to bring the mixture to the right consistency.

(2.) Rotten stone .... 8 ounces
Oxalic acid .... 2 "
Cotton seed oil .... 3 "
Benzine, enough to bring the mixture to the consistency desired.

—American Druggist.

Preserving Lemon Juice.—Various means have been resorted to for the preservation of lemon juice, but none of them seems to make it retain its original flavor unaltered. As preservatives, alcohol, salicylic acid, bisulphite of lime, formaldehyde, etc., have been recommended. Probably as satisfactory a method as any is to clarify the liquid by heating it with a small quantity of albumen in a suitable vessel, without stirring, to near the boiling point of water, until the impurities have coagulated and either risen to the top or sunk to the bottom. It may be then filtered through a twill cloth filter containing some filtering powder, into clean bottles, which should be completely filled and closed (with pointed corks), so that each cork has to displace a portion of the liquid in order to be inserted. The bottles are sealed and kept at an even temperature (in a cellar).—Pharmaceutical Era.

To Make Ground Glass.—There is a time in every amateur photographer's photographic life when he feels the need of a bit of good ground glass, and use can be found for a number of pieces in various ways. Nothing is better to print a soft negative under than a bit of ground glass; nothing acts so well as a diffuser of light for enlarging or reducing, and yet how few use it! A spoiled plate stripped of the emulsion can be changed into a good bit of ground glass in about half an hour by the following procedure: Procure from the kitchen tin about a teaspoonful of emery powder, used for cleaning knives, etc.; put this in the center of a large piece of common glass resting on a flat surface —nothing is better than several thicknesses of newspaper on a table. Then, taking a cabinet print cutting-shape with a knob, rub the emery powder hard. This is merely a preliminary, and grinds down the larger pieces which would scratch the piece destined to be ground. Now, collecting the emery, put it aside for a moment and fix the piece of glass to be ground in the place of the other. Put a little emery in the center, and, with the cutting shape pressed steadily, move rapidly with a rotary motion, grinding the surface, adding more emery as it is used up. At first it will be found that the surface will be covered with scratches and the work looks spoiled; but if the action is continued steadily, less than half an hour will finish a piece far superior to that usually sold in the shops.—Pottery Gazette.

Tableting Glue.—A screw press, with a piece of smooth board on the bottom and a block above to clamp and hold the paper, answers very well as a tableting press. After the paper is squared up and all edges even, place in the press and fasten securely. Apply tableting glue to the top edges by means of a flat bristle brush. Allow to remain in the press until glue is dry. The following formula makes a satisfactory glue for tableting paper:

Good clear cabinet glue	4	oz.
Acetic acid	3	fl. "
Water	2	" "
Glycerin	½	" "
Aniline (any color preferred)	q. s.	

Place the glue, acetic acid and water in a wide mouth bottle or jar, set in a warm place and stir occasionally until glue is dissolved. If needed at once the process may be hastened by dissolving the glue by means of a water bath. Add the glycerin and enough of a solution of aniline in water to give the desired color. Should the glue become too thick, add a little water till the proper consistency is restored.

This preparation has the advantage of being easily made, and is always ready for use.

Printing to be tableted should be permitted to dry thoroughly at least twelve hours before being placed in the tableting press, otherwise it will "set off"—that is, partially transfer the impressions and soil the backs of the sheets.

Black Enamel for Bicycles.—

(1.) Oil tar .... 16 ounces
Asphaltum .... 4 "
Resin, powdered .... 4 "

Mix and dissolve with the aid of heat over a water bath, care being taken to prevent contact with flame.

(2.) Amber .... 16 ounces
Linseed oil .... 8 fl. ounces
Asphaltum .... 3 ounces av.
Resin .... 3 " "
Oil turpentine .... 16 fl. ounces

Heat the linseed oil to boiling and add the amber, asphaltum and resin; when melted, remove to the open air and add gradually the oil of turpentine.

ENGINEERING NOTES.

The Simplon tunnel, which will pass under the massive rock of Monte Leone, from Brique, in Switzerland, to Isella, in Italy, will be 19,731 meters in length, and attain at its highest point an elevation of 705·20 meters above the level of the sea. The chief difficulty to overcome is the temperature, which in the interior rises to 40° C. There will be two tunnels running parallel with each other at a distance of 17 meters, the first to be finished completely, and to occupy an ordinary broad gage line, while the second will for the present only constitute a gallery, with a view to its being enlarged into a second tunnel when the traffic may demand it in after years. The motive force for construction will be furnished at Brique by the Rhone and at Isella by the rivers Divera or Caisasca.

Mixing compressed air with the steam in an engine cylinder, with the view of securing greater economy owing to reduced cylinder condensation, has been a favorite engineering topic for some years, says Cassier's Magazine, and experiments have been made to ascertain what economic benefits might be hoped for from this practice. The latest of these trials, which were carried out not long ago at Stevens Institute, ought, for a time at least, to put a damper on further agitation in this line, having demonstrated pretty clearly that, when all circumstances are duly considered, there is no saving to be obtained from the admixture of the air. Four series of tests were made with air at different temperatures and in various proportions, and in these the best results showed a saving of about 7 per cent., but this was almost exactly offset by the power required to compress the air.

The shipping industry on the Caspian Sea has of recent years assumed very large proportions in consequence of the increasing demand for tonnage for the transport of the mineral oil products which now find a sale in Russian markets throughout the empire, especially in the manufacturing centers on the banks of the Volga, where crude oil is extensively used for fuel. The consumption of oil for purposes of fuel on certain Russian railways and by all the steamship companies on the Volga continues to augment, and the requirements to meet the traffic with Central Asia and Persia are also rapidly growing. There are at present over 200 vessels of different descriptions plying on the Caspian Sea, but there is a great scarcity of tonnage, and several orders have recently been put in the hands of shipbuilders for new steamers with a carrying capacity of from 900 to 1,200 tons. All of these will use oil fuel, says the Engineering and Mining Journal. That most usually burned is the astatki, or residuum from the refineries.

The water cosumption of Paris, says the Revue d'Hygiene et de Police Sanitaire, touched its maximum on July 9 last, with 633,200 cu. m., or 167,290,440 United States gallons per day. Of this volume 64,042,080 gallons were derived from springs, or "eaux de sources;" 62,826,760 gallons were taken from the Seine, 39,101,600 gallons came from the Ourcq, 1,321,000 gallons came from the artesian wells or from Arcueil. Between July 5 and 11 the aggregate consumption was about 62·4 gallons per day per inhabitant, of which only 26 gallons, however, was from the springs, or sources of purer water. While the Parisian authorities note this consumption as abnormal and due to a season of unusual heat, the figures given prove either that the supply of potable water is a limited one or that there is unusual care in its distribution. Considering the very liberal public use of water in fountains, etc., in that city, the aggregate daily consumption per head of population is very small compared with the lavish use, or waste, of water in American cities. And in the latter cities the best water is used for all purposes, instead of there being several distinct supplies of varying quality to draw upon, as in Paris.

A meeting of gentlemen interested in the movement to establish a public national railway museum in London has been held recently under the chairmanship of Mr. Rous-Marten, when the scheme was fully discussed, and steps were taken to give the movement a concrete form, says The Engineer. It was resolved that those present should constitute a committee with the title of the National Railway Museum Committee. The committee thus formed consists of Mr. C. Rous-Marten, Mr. Archibald Sturrock, Mr. A. R. Bennett, Mr. J. Sinclair Fairfax, Mr. Perry F. Nursey, Mr. F. McDermott, Mr. G. F. Bird, Mr. C. H. Grinling, Mr. H. Greenly, Mr. J. H. McDowell, and the Rev. W. J. Scott, with power to add to their number. Sir David Salomons and Mr. C. Rous-Marten were unanimously elected chairman and vice-chairman of the committee respectively, the election of a president and vice-presidents being postponed. It was also resolved that Mr. Stretton be appointed honorary general secretary, and that Mr. Norman D. Macdonald and Mr. F. W. Brewer be appointed honorary secretaries for Scotland and London respectively. It is proposed that the museum be situated in London, and that an appropriate home for it would be South Kensington Museum.

Coal mining in Japan has made remarkable progress during the past two decades, according to the Tokio Economist. In 1875 the output was a little over 560,000 tons; in 1893 the supply was over 3,307,000 tons, and those engaged in the business estimate the subsequent output at 10 to 20 per cent. higher. About half of this yield is consumed in the country, and the remainder goes to Hong Kong, Shanghai, Chefoo, Newchang, Singapore, and San Francisco. Hong Kong took about 600,000 tons last year for steamers and factories, Cardiff coal at present currency prices finding no market for ordinary use in the East, and the possible rivals of Japan in the future for the supply of the markets—Tonquin and Australia—being as yet of little account. In Shanghai, Newchang, and Singapore, Japanese coal is used not only for steamships and factories, but also in the kitchen. In San Francisco it is employed for generating gas; but the price there forbids its extensive use, and no reduction is probable, since the ships that would carry coal to that point would find it hard to get a return cargo. The chief sources from which the exported coal is obtained are the collieries operated in Miike, Kyushui, and Hok-Kaido. What their capacity is can only at present be conjectured. Eight or nine years ago the coal fields owned by the navy department in Kyushui were so unpromising that mining there was stopped.

ELECTRICAL NOTES.

The small town of Marieham, in Finland, takes the lead as the best telephoned town in the world, there being one telephone to every 13 inhabitants.

The longest commercial distance at which the long distance telephone is now operated is from Boston to St. Louis, a distance of 1,400 miles, says the Electrical Age. This line is more than twice as long as any European telephone line.

A plan is under ventilation for transmitting by electricity the power of the Wallinkoski waterfall, in Finland, by means of overground wires, to St. Petersburg. Applications have been made to the Finnish authorities for the necessary concessions.

The Aarau water power station, which was visited on the occasion of last autumn's electrical congress at Geneva, is described in L'Electricien. The source of power is the River Aar. Reaction turbines are used, with alternators direct coupled on the main shaft. At 48 revolutions these machines give two-phase currents at 2,000 volts. There is a pendulum regulation of the inlet gates. The exciter dynamos are also on the main shaft. There are three transmission lines. The town station is about half a mile off. These three motors, each working a pair of dynamos, convert the current into a continuous one for lighting purposes. There is also an accumulator of Tudor cells.

An underground electric railway has been constructed in Berlin (Germany) by the Allgemeine Elektricitäts-gesellschaft. The tunnel is about 330 yards long, and the entire length of the line, connecting two factories of the above named company, is only a quarter of a mile. Overhead conductors are used, and within the tunnel a copper strip or rail 2⅜ by ⅛ inch is employed instead of a wire conductor. The return circuit is made partly through the rails, which are connected by bars of copper, and partly through a cable which is electrically connected to the rails at intervals. This is done to reduce leakage and to lessen the effect of the high tension currents on the telephones and other apparatus in the factories.—Uhland's Wochenschrift.

Mr. Clarence A. Saunders' researches on the velocity of electric waves are published in a contemporary. A novelty in his method is to check the velocity of the rotating mirror by a motor accurately regulated by a synchronous alternating motor on the same axle instead of the old method on a tuning fork. Mr. Saunders' average values are 29,820 and $29{,}970 \times 10^6$ cm.-sec., the larger number resulting from using a longer circuit. If the wires were perfect conductors, says the Electrical Engineer, the velocity of propagation should be the same as that of a wave in the dielectric—i. e., to the velocity of light—and theory indicates that in the present case the error due to the resistance of the copper wires would be too small to be taken into account.

At present there are in use in America from 150 to 200 miles of street railway track, the joints of which have been all welded, either by the electrical or the "cast welding" system, so that the rails are actually continuous. As to the success of this system, the testimony is rather conflicting; but the fact appears to be that the difficulties encountered have been no more serious than might naturally be expected to accompany so novel a departure from usual practice. The cast-welding system promises to supersede the electric-welding system, says the Engineering News, because it produces as good or better results at a less cost. Unless some further trouble should develop, or those already found should prove more serious than they thus far have done, it seems quite probable that the street railway track of the future will have a continuous rail, at least, wherever it is laid in paved streets.

"**The stories** of magnetic mountains that exert an attraction that cannot be withstood on all vessels that come into their vicinity has some foundation in reality," says Der Stein der Weisen (Vienna), "and that, too, in the neighborhood of Germany. The well known island of Bornholm, situated in the Baltic and belonging to Denmark, may be regarded as a huge magnet. Although the power of this magnet is not so great that it can draw the nails out of ships, as was told of the legendary magnetic hills, the magnetism of the rocks on the island of Bornholm can cause a good deal of trouble to ships in quite another way. For the island of Bornholm exerts such an influence on the magnetic needle that it can cause a vessel to turn perceptibly aside from its course. This is quite possible, as the effect of this magnetic island is perceptible at a distance of 15 kilometers (9⅜ miles). A rocky reef near Bornholm is also made of the same magnetic substance."

Why should an electric car be more severe on the rails than a steam locomotive? asks the American Engineering News. Take, for example, a modern high speed steam locomotive for heavy service. There is the driving wheel, 6 ft. or more in diameter, the weight of half the driving axle, and one eccentric, the weight of the axle box and part of the spring, and finally the weight of the parts attached to the wheel, which, in case of the main driver, are the crank pin, counterbalance weight, half the weight of the parallel rod, and more than half the weight of the connecting rod. When we have summed up all these weights, we find a total load on the rail not supported by springs, which may equal or exceed the load that is not spring supported on an electric car wheel tread. Further, the electric car may run at an average speed of eight or ten miles per hour, while the locomotive averages three or four times this; why, then, should not the locomotive be more severe upon the tracks than the electric car? Again, it is to be remembered that the cable railways also experience more or less trouble with their track joints, though not as much as the electric lines. It would appear from this that the conditions under which street railway track is laid and maintained may have something to do with the joint difficulties. Perhaps the fact that on a railway in a paved street the joints are let alone until their condition becomes so bad as to compel the removal of the paving to make repairs has something to do with the troubles experienced. On steam railway lines, as is well known, the way to keep a track in good condition is to constantly take the "stitch in time" that saves nine.

MISCELLANEOUS NOTES.

The experiments carried out in India with the new Lee-Metford bullet go to show that it has advantages other than those connected with its stopping powers, says the Army and Navy Journal. At 500 and 1,000 yards it gives, it is said, a better target than the present service bullet; there are practically no ricochets, and it wears away the rifling of the barrel very little indeed. A slight alteration at the base of the bullet saves the barrel, which will thus have a longer life—a very important consideration.

There are 760 lights on and around the coasts of the British Isles, against 510 in France; but the aggregate luminous power of the French lights is the greater. The total British seaboard is 3,800 nautical miles, while that of France is 1,692, so that the latter has an average of one light for about every three miles, against a light for each five miles in Great Britain. In oil and gas lights the British Isles have about one-third more mean power per light, but in electric lights France has 2·6 as much power as England. The Electrical Engineer suggests that this is perhaps due to the perfectly unfounded prejudice which has obtained possession of some people in England that the electric light does not penetrate in foggy weather.

European doctors are trying to find out what use can be made of Roentgen rays in the treatment of disease. No decided results have yet been obtained from the experiments with the rays on the various kinds of microbes, but Prof. Loitet, of Lyons, who inoculated two sets of guinea pigs with tuberculosis, found that those exposed to the rays showed no sign of disease, while in the other tuberculosis followed its regular course. Dr. Ausset exposed the abdomen of a seven-year-old girl, afflicted by pulmonary and abdominal tuberculosis, to the rays for an hour daily for three weeks. During that time she improved and gained flesh, but, on the treatment being discontinued through the loss of the apparatus, she grew worse rapidly and soon died. Dr. Freund, of Vienna, has removed a pigmented hairy growth that covered the whole back of a four-year-old child by exposure for ten days to the action of the rays.

The Welsh tin plate industry has lately looked a little brighter in consequence of increased exports to the United States, but it cannot be too often repeated that, as a chief market for the tin plate industry, America no longer exists, says Industries and Iron. There are now nearly forty firms in the United States engaged in the manufacture enjoying all the advantages of the newest and completest machinery. The ability of the home manufacturers to supply their own markets cannot be questioned; it is only a matter of time. We observe that a new tin plate organization is suggested in the United States, which is to include the manufacturers who have not joined the present combination. It is stated that one of the objects for which a meeting of the whole organization is to be called is the possibility and expediency of reducing present prices. This is rather a novelty among manufacturing combinations; the tendency is usually the other way. But the desire evidently is to choke off competing imports.

The Pittsburg Gazette says: "When the railroads are accused of penuriousness and bad judgment, because during times of phenomenal boom in the coal and coke business they cannot provide sufficient cars for the traffic, their accusers never take into consideration the enormous equipment devoted to this particular kind of freight, which is idle one-half the time. The coal and coke business is liable to extraordinary fluctuations, and while at certain periods a road like the Pennsylvania could find use for 75,000 coal and coke cars, yet normally the traffic does not require more than 10,000 cars. It is safe to say that during the past seven months the Pennsylvania and Pennsylvania lines have had 20,000 cars standing idle on sidings and middle tracks. These cars represent an investment of at least $15,000,000, and when a company consents to place that vast sum of money in rolling stock with no hope of obtaining profit or interest from it during one-half the time, they ought to be given credit for self-sacrifice in order to encourage industry, instead of being denounced as penurious and unaccommodating. In addition to the cars, the cost of motive power and extra tracks, all of which are kept in reserve for a rush of business, which comes only periodically, must be considered. It has been estimated that the Pennsylvania system has $30,000,000 invested in equipment and tracks which are not used more than half the time."

The dangerous properties of water gas as compared with coal gas, which was a live question fifteen or twenty years ago, when the gas companies in the large cities began to change their systems of manufacture from the old retort system to the Lowe water gas system, is now under discussion in Boston, and reports on the subject have been submitted to the Legislature by the committee on manufactures, says the Engineering Record. It appears that the number of deaths in the city of Boston, resulting from the inhalation of gas, has greatly increased in recent years, the figures being as follows: 1893, 23; 1894, 26; 1895, 22; 1896, 43. The consumption of gas has increased over 43 per cent. in three years, notwithstanding the great increase in the use of electric light. The majority report says that this increase in gas consumption is due to the decrease in its price, consequent upon the reduction in cost made by the use of the water gas process; that the increase is chiefly in the tenement house districts and among the poorer classes, and that the increase in the number of deaths is due to the increased use of gas, and that in almost every case the fatal result was due to suicide, drunkenness, carelessness, or ignorance. The minority reports says that the increase in the number of deaths is due to the substitution of water gas for coal gas; that it was a mistake in 1890 to allow the manufacture of water gas, which mistake it was easier then to make than it is now to remedy. The minority of the committee, believing that prohibition of the manufacture of water gas is now a practical impossibility, suggests the passage of an act to compel the operation of the existing coal gas plants in Boston, and the mixing of the coal gas with the water gas, so as to reduce the carbonic oxide in the mixture to below 16 per cent. and to prohibit the distribution of gas containing a higher percentage of carbonic oxide.

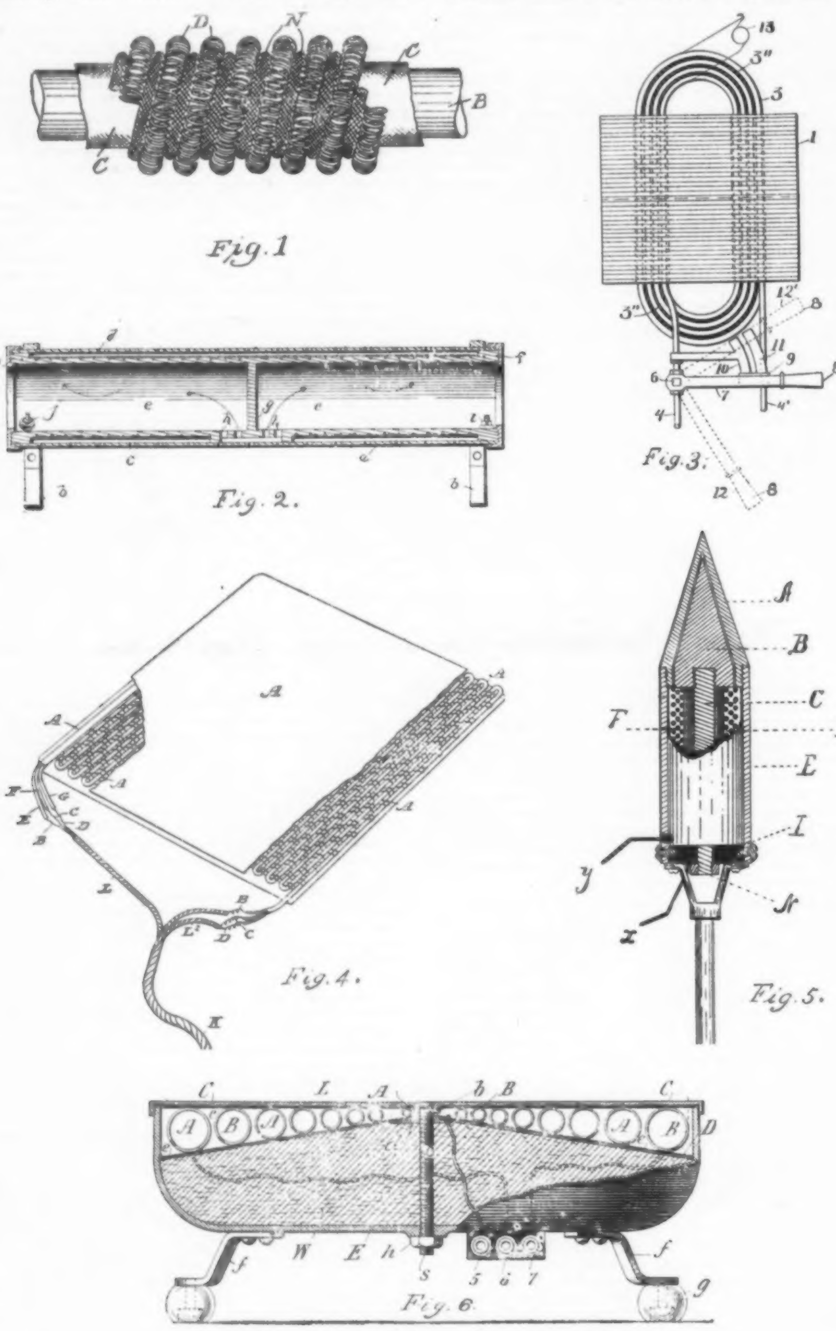
THE ELECTRIC HEATER.

By H. E. Stauffer.

The subject of electric heating is to-day receiving much attention. The remarkable growth of the electric railway and the extensive distribution of electricity for lighting and power have both contributed largely to bringing the electric heater into prominence. The readiness with which the current can be applied to the heating of cars, together with the high efficiency of the electric heater as a means for transforming electric energy into heat energy, have caused this form of heater to practically supplant all others on electric railways. And, while its adaptation in the household has been by no means so marked as its use on electric cars, it has, nevertheless, begun to take its place with the electric light as an adjunct to the modern house. Also, in many of the arts where it is necessary to concentrate heat at a particular point, or where it is undesirable or impossible to use a fire, the electric heater has been found most valuable. Its constant readiness, its cleanness, its cheapness, its portability and the ease with which it can be managed, all render it a highly desirable means for obtaining heat wherever it can be used. The present cost of operation, however, almost precludes its use for many purposes for which it is most highly suitable.

But it is not the purpose of this article to set forth the advantages or disadvantages of the electric heater, or to discuss the merits or demerits of any particular form or system, but to only give a general description of some of the more recent forms and to show how they are applied and used in such a manner and to such an extent as to illustrate the general progress of the art.

To this end, attention is first called to the heater shown in Fig. 1. This figure illustrates a portion of a heater designed for heating cars, the intention being to heat the air directly by causing it to come into contact with the heated resistance wires. It is here shown without a casing, in order that the construction may be more apparent. It consists of a great length of resistance wire, loosely coiled so as to present a considerable radiating surface, which is wound into a spiral around a core of earthenware, porcelain or some other non-conducting and non-inflammable material; or the core may be a metallic one covered with insulating material. The latter is the construction shown in the figure. When the coil is wound upon the core, it is somewhat extended, so as to prevent the convolutions thereof from coming in contact with each other.



VARIOUS FORMS OF ELECTRIC HEATERS.

In the figure, B designates a metallic core covered with an insulating medium, C, over which is wound the resistance, D. N is insulating material wound between the coils to prevent them from coming in contact. The casing is usually only a semicircular back, having a reticulated front plate attached thereto through which the air circulates, the air entering the box through the openings in the bottom of the face plate, passing round the heater and out through the openings in the upper part of the plate.

By this construction it is possible to place within a small space a very large amount of bare wire and yet avoid all danger of short circuiting. Nor is any difficulty occasioned by the expansion of the wire when heated, for all expansion thus occasioned is taken up by the coils themselves by reason of their inherent elasticity. When used for warming cars, the heaters are usually attached to the risers which support the seats, some of the panels being removed and the heaters set back in the openings thus formed until their faces come flush with the risers.

Another form of air heater designed for warming cars, dwellings, etc., is shown in Fig. 2, the view being in section to clearly illustrate the construction. Here e is a cylinder of fireproof material, around which a resistance wire is wound, the resistance being covered with a coating of talc and silicate of soda mixed with water to form a paste. The cylinder is provided at either end with a flange, f, projecting a little above the surface of the tube to receive an outer casing, a, which is perforated to permit the air to circulate through the same around the core. In the particular form here illustrated the inner cylinder is provided with a diaphragm, g, which divides it into two compartments substantially equal in size. This is to prevent the air which enters the openings, h, with which the bottom of the tube is provided, from all passing out at one end of the heater. In operation, air enters the perforations in the outer casing and passes around the outside of the heated core, and also through the openings, h, and through the interior of the core. Suitable supports, b, are provided on which the heater stands. Should the resistance wire be burned out, the core carrying the same may be removed and another substituted therefor.

The electric heater is particularly useful in places where heat is needed, but where, from some reason, it is either impracticable or impossible to use an ordinary heater. The oil well is an instance. As is well known, an oil well, after having been used for a certain length of time, becomes practically useless as a producer, because the crevices in the rocks through which the oil flows become more or less filled with paraffin, which deposits from the oil, and thus shuts off the flow. To overcome this difficulty, the practice has usually been to "shoot" the well, that is, to explode torpedoes therein. This widens the existing crevices or forms new ones, through which the oil again flows. This process, however, does not remove the paraffin, but only drives it back into the crevices, and, therefore, while the widening of the crevices serves to make the well again produce for a time, it does not remove the real obstruction. Many plans for removing this obstacle have been suggested, one of the most successful of which is the electric heater. The ease with which the heat required can be electrically generated at the point desired, and the facility with which any needed quantity can be supplied, both make the electric heater an ideal one for this purpose.

Several devices designed especially for this work have been produced. A brief description will be given of one of the most recent forms. It comprises a central core several feet in length of some insulating material, around which a resistance is wound. Surrounding this, but insulated therefrom, is a long slender casing which entirely surrounds and hermetically seals the core and its resistance. This casing is of metal, and the terminals of the coil are properly insulated and passed out through the top thereof in order that they may be readily connected to a generator. This casing is surrounded by still another. This latter is of such size as to leave an annular channel about one inch wide between the two and is open at both top and bottom. The heater and its casing must be somewhat smaller than the bore of the ordinary oil well, so that a second annular passage is formed between the wall of the outer casing and the wall of the well. This apparatus is intended not to melt out, but to dissolve out the paraffin. It is well known that paraffin readily dissolves in a number of substances, when such substances are in a heated state, common solvents being coal oil and gasoline. If the well to be operated upon has oil already therein, and they usually have a small amount, it is the purpose of the inventor to simply lower the heater in the well until it nearly reaches the bottom and then turn on the current. Thereupon the heater will immediately become hot and communicate its heat to the oil, which latter will begin to rise through the annular channel between the inner and outer casings of the heater. By this means the contents of the well are set in motion, circulating up through the heater and down between the outer casing thereof and the wall of the well. In time this oil becomes highly heated and will then readily dissolve the paraffin wherever it comes in contact with it; and, because the oil is in motion, it will work its way into and through the crevices in the rocks through which the oil flows, and thus dissolve away the wax which has closed them up. After running the heater for several hours, it is removed, and the oil and dissolved paraffin removed by means of a pump.

If the well is dry, that is, has no oil therein at the start, a barrel or two of oil can be poured in before the heater is placed in position. Of course, the operation will then be the same as that just described. In the one case, the solvent is already in the well; in the other, it is supplied by the operator.

Another use to which the electric heater has been put and where it seems destined to fill a long felt want is to heat liquids while in motion, for instance, water moving through a pipe, so that it may be delivered to the user in a heated condition. By means of such devices, to secure hot water, all that it is necessary to do is to turn on the current and then turn on the water, whereupon the water will be delivered in a heated state. The temperature of the water can be readily regulated either by varying the amount of current supplied to the heater in any of the well known ways, or by varying the velocity of the current of water flowing through the heater, or both.

A recent form of heater designed for this purpose is shown in Fig. 3. In this form it is, in fact, a converter, with the secondary made hollow. Its construction is really very simple. It comprises in general only a primary coil, a hollow secondary coil, an iron core, a valve for governing the flow of the liquid through the secondary and a switch for closing the circuit between the terminals of the secondary. The parts are so proportioned that the secondary will be heated by the currents which are generated therein by the primary.

In the figure, 1 designates a laminated iron core, which is perforated so that the coils may be passed through. 3 indicates the hollow secondary. The primary coil is not shown, being directly behind the secondary; it consists, however, as in all alternating step-down converters, of a long length of fine wire wound into a coil. 4 designates the end of the secondary at which the liquid is supposed to enter, and 4' that at which it escapes. 6 is a valve in the secondary near the entrance end. This valve is actuated by means of a lever of insulating material, 7, having a handle, 8. On the lever is mounted a contact plate, 9, which serves to short circuit the terminals of the secondary by connecting the plates, 10 and 11. The plate, 9, rests against the plates, 10 and 11, so that it may be moved over the same in adjusting the valve, which is done to vary the amount of liquid which shall flow through the pipe. 12 and 12' show in broken lines two positions of the valve lever. When this lever is in the lower position, the valve is closed; when in the upper position, partially closed; and when it is in the position shown in full lines, it is fully open. 3" indicates the insulation between the coils of the secondary. The generator is conventionally shown at 13.

To operate the apparatus, it is only necessary to turn the current into the primary coil by any suitable means, short circuit the secondary and open the valve. The last two operations are performed simultaneously by raising the lever, 7. The switch which controls the primary coil may also be attached to and actuated by the lever. The device may be used to furnish heated liquid for any purpose, but it is more particularly designed as a generator for hot water and steam circulatory systems and as an instantaneous water heater for household purposes.

Another place where the electric heater has been recent-

ly employed, and where it seems to fill a long felt want, is in the sick room, as a substitute for hot water bags, hot cloths, etc., in warming patients. For this purpose the heater is made flexible, so that it can be made to conform to any part of the body. The electric heater seems most admirably adapted for this purpose. The ease with which it can be moved about and applied whenever and wherever needed, its constant readiness and the ease with which its temperature can be controlled, all render it a most satisfactory substitute for the old apparatus used for this purpose.

Fig. 4 illustrates such a heater. It is a woven fabric, the warp threads whereof are of asbestos or other suitable insulating non-combustible material, and the woof threads of the same material, with three separate continuous and insulated resistance wires embedded therein and forming a part thereof. These conductors, therefore, are woven into the fabric and become a part of the same. By inserting a plurality of resistance wires, the heat can be readily varied by varying the number placed in circuit. For instance, if only a slight heat is wanted, one conductor may be thrown in circuit; if a greater amount is desired, two may be used; if still more, all three. The current, and, consequently, the heat, could, of course, be governed by a rheostat, but the above described construction avoids the necessity of any such instrument, and yet effects the necessary regulation. A suitable switch for throwing one or more of the conductors into circuit is always provided. In the figure, A designates the body of the heater. B, C and D represent the resistance wres, and E, F and G the insulation thereon. L, L' and L² are the conductors which connect the wires to the switch. The entire heater is covered with some suitable material which protects the structure and adds a finish of the character desired. It may be of any suitable size, even large enough to entirely envelop the patient.

As a means for heating soldering irons and flat irons, the electric heater has been found very satisfactory. These implements, when in use, are almost constantly in motion, and, consequently, it is next thing to the impossible to apply to them any permanent heating means but the electric heater. Thus heated, the iron may be used indefinitely without change or rest.

A soldering iron heated in this manner is shown in Fig. 5. In this instance the heater is not simply a resistance coil, but is a combined resistance and induction apparatus. It is designed to be used with an alternating current, and comprises a primary coil, a secondary coil short circuited upon itself and a hard magnetic core. In the figure, A designates the point of the iron, B a magnetic plug therein, having an extension, C, of magnetic material, the two constituting a core. The extension, C, of the core is surrounded by a layer of iron wires, D. The core and wires, D, are surrounded by a resistance wire, F, the terminals of which are x and y. E is a metal casing surrounding the coil and core. This casing is also the secondary coil of the apparatus, it being of such a resistance as to be materially heated by the currents induced therein. I is an insulating plug and N a binding nut. When an alternating current is passed through the primary coil, this coil becomes heated by reason of its resistance; the shell becomes heated by the currents induced therein, and the magnetic core becomes heated by hysteresis or magnetic lag due to its changes in polarity. It will, therefore, be seen that the entire apparatus becomes quickly heated, and constitutes a very satisfactory heater for the purpose intended.

In heaters having large, flat surfaces, such as cooking stoves or tables, sad irons, etc., no little difficulty has been experienced in securing a uniform distribution of the heat at different points on the surface. One means for overcoming this difficulty is shown in Fig. 6. A resistance wire of the ordinary kind is used. This is wound on a tapered mandrel, so that, when coiled, it presents the form of a helix, one end of which is larger than the other, the increase in size being regular and gradual. This helix is then disposed in the form of a spiral, beginning with the smaller end, which thus becomes the center of the spiral, so that the convolutions of the spiral and the convolutions of the helix both increase in size together as the distance from the center is increased. It will, of course, be readily seen that a unit length of the helix will include a larger amount of wire, and, consequently, have a greater resistance, at the outer end than at the inner. Therefore, it is equally clear that when such a coil is disposed on a plate in the form of a spiral, the plate will be heated to a practically uniform temperature over its entire surface, the excess of radiation from the parts more distant from the center being offset by the excess of heat supplied to these parts.

In the form of heater shown in the figure two enameled plates are provided, one a plain, flat plate and the other somewhat conical in form, to conform to the outline of the coil when in position. These plates are united at their centers and the coil is wound between them. In this particular instance two coils are used, they being laid side by side in alternate spiral paths. Each is provided with terminals, so that either or both may be thrown in circuit, according to the amount of heat required.

Referring now to the figure in detail, A and B designate the coils and C and D the enameled plates, the enamel being shown at E. A threaded boss, b, is arranged on the under side of the plate, C, and the plate, D, is provided with a perforated and threaded boss, d. A metal base, E, provided with feet, f g, supports the plates and coils, and is rigidly attached thereto by means of a screw, s, and nut, h, the screw being passed through the boss, d, the threads of which it engages, and into the boss, b. By this means the parts are rigidly secured together, and at the same time the plates may be turned independently to vary the tension of the same upon the coils. The space between the plate, D, and the base, E, is filled with mineral wool or some other non-conductor of heat, W. The terminals, 5, 6 and 7, of the coils are fastened to the bottom of the base, E.

The same principle has been applied to sad irons. When thus applied, the helix, instead of being wound on a tapered mandrel, is wound upon one which increases in size by distinct steps, by which means there is produced a helix composed of two or more continuous sections, the convolutions of each section being all of equal diameter. For heating sad irons, the helix is usually wound in three sections. The base of the iron is provided with grooves, and the upper surface thereof is enameled.

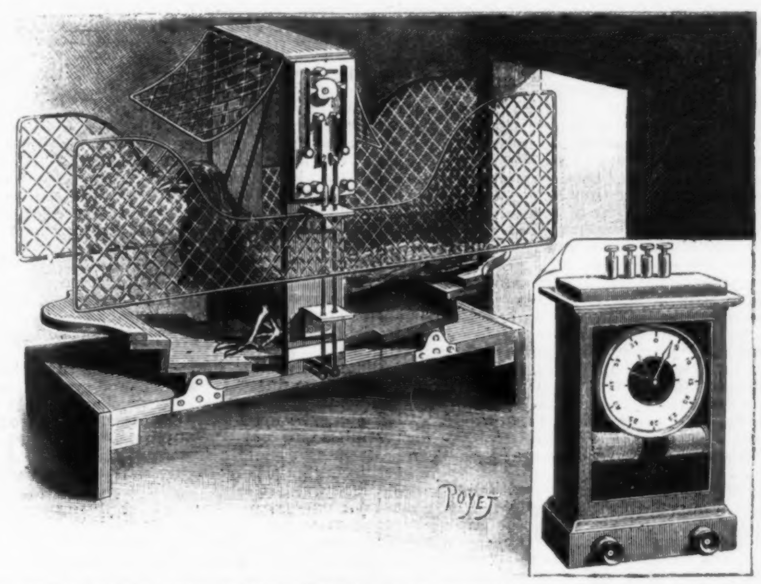
It is a matter of common knowledge that the rear portion of a sad iron loses heat more rapidly than any other portion, while the center loses the least. Therefore, when the iron is built, the smaller end of the helix is wound upon the center of the base; that which is next in size is wound upon the sides; and that which has the greatest diameter upon the rear portion. By this means an admirable distribution of the heat of the coil is effected.

The uses to which the electric heater have been put are very numerous, and many special forms have been produced for special purposes. No attempt, therefore, has been made to do more than give a brief description of some of the forms which have been more recently produced and show how they are to be used. The art is a growing one, and the time is doubtless near at hand when the electric heater will be a far more common sight than now. However, from the very nature of things, it cannot come into general use for household purposes until the current is produced much more economically than now. The cost of the current almost precludes its use for this purpose at the present time.

APPARATUS FOR REGISTERING THE OUTGOING AND INCOMING OF CARRIER PIGEONS.

Carrier pigeon fanciers are becoming more and more numerous, and, in view of the important role that the bird plays in time of war, and that it is now playing in Madagascar and Tonquin, this is a thing to be rejoiced at. It is unnecessary to say that at such a time it is of the greatest interest to prevent any delay in the transmission of a dispatch carried by a pigeon, and, as a general thing, a watcher is intrusted with the duty of awaiting the bird's arrival. Aside from the fact that this man sometimes frightens the pigeon and prevents it from immediately entering the cote, one has to run the risk of negligence or dishonesty on his part.

These are inconveniences that are suppressed by the



APPARATUS FOR REGISTERING THE OUTGOING AND INCOMING OF CARRIER PIGEONS.

Vilpou electric registering apparatus, which permits the fancier to inform himself as to what is taking place at every instant in his cote, to verify the entrances and exits, and to learn whether strange pigeons have entered, etc. In order to learn all this, he has only to take a glance at the registering apparatus placed in his office, bedroom or parlor, so that there is no longer any need of his climbing up to his cote.

The apparatus consists of two parts, of a manipulator or automatic door and a registering device. The first of these consists of a sort of a wooden portico, between whose uprights there is a space of about 2 in. The two uprights are joined at the top by a horizontal bar of wood that supports a wire wicket mounted upon two pivots. When the wicket is pushed either backward or forward by the pigeon, it comes into contact with an electric tappet arranged against one of the sides of the frame. On each side of the wicket there is a pedal, which, at the passage of the pigeon, is depressed and interrupts the current.

Moreover, one of the uprights of the frame carries a small bar of wood capable of being turned down so as to arrest the wicket in case it is pushed toward the exterior. In consequence of this ingenious combination, it is possible to prevent a pigeon from making its exit, while allowing those that are still outside to enter the cote.

The object of the lattice work at the sides is to prevent the birds from making their way out in that direction or from stationing themselves near the entrance of the cote. The birds hasten to make their exit through the narrow passage, and in this way the access to the apparatus is always free.

It is easy to accustom the bird to experience no fright at the sight of this manipulator and at the slight resistance that it encounters in maneuvering the wicket.

The registering device, which may be placed as far away from the cote as may be desired (it is only a question of wire), comprises a clockwork movement actuated by two electrodes. It does not, therefore, have to be wound up. Over a dial that carries 60 divisions move two hands, the larger of which is designed to mark the divisions up to 60 and the smaller one those above 60. The dial is thus capable of registering the exits or entrances of 360 pigeons. There is no cote that possesses such a number. Moreover, for more than fifty pigeons, it is necessary to have two manipulators. When all the pigeons are in the cote, the hands of the registering device should be at zero. For their exits the hands move in the direction of those of a watch, and, for their entrances, in a contrary direction. After the readings have been made, the hands are placed at zero by a pressure upon buttons provided for that purpose upon the face of the apparatus.

Besides this indication, which is very accurate, the pigeon, in passing over the pedal, may actuate an electric bell that announces its entrance or exit.—L'Illustration.

THE COMMENCEMENT OF SUBMARINE TELEGRAPHY.

By J. H. Jackson, in the Nautical Magazine.

It is at once interesting and difficult to try to discover to whom is due the honor of inventing submarine telegraphy. Many nations have claimed the distinction, but so far as research enables a judgment to be passed, the palm must be awarded to a Russian scientist, Prof. Soemmering. This gentleman, in the year 1807 or 1808, first practically proved the possibility of so insulating a wire as to enable an electrical current to pass through it when immersed in water. His experiment took the form of exploding a small charge of gunpowder across a river. This experiment was repeated during a visit to France in 1815, and to his success in igniting the same explosive across the Seine we may attribute the attention which was at once aroused in the minds of all scientific men. They were quick to perceive that in these useless exhibitions there existed the germ of great potentialities. When, therefore, a few years afterward, Prof. Soemmering suggested to the Russian government the construction of a short cable connecting Cronstadt with St. Petersburg, he was favorably received and the requisite authority given. For some reason or other, not quite plain now, the project never became realized. This failure enabled an Irish doctor, resident in India, to be the first in the field with a practical telegraphic cable. In 1839 this Dr. W. O'Shaughnessy constructed in Calcutta a copper wire coated with cotton thread saturated with pitch and tar, and with it transmitted signals from one bank of the Hugli to the other. In 1840 Prof. Wheatstone got the House of Commons to pass a scheme for a Dover-Calais cable, but nothing followed until ten years later. The brilliant success of the Irish experimenter was followed in 1842 by the laying down of a cable between Governor's Island and Castle Garden in New York, by Mr. Morse, whose name subsequently became a household word in matters telegraphic.

In 1844 Prof. Wheatstone transmitted messages to the Mumbles lighthouse from a vessel anchored in the bay; two years after this Mr. West laid a cable across Portsmouth Harbor. This was intended as an advertisement to encourage the French and English governments to proceed with a line connecting the two countries. Meantime, Americans were not idle, for in 1845 Ezra Cornell placed a two miles' length of cable between Fort Lee and New York, but the following winter's ice soon disposed of it. In 1847 Mr. Craven, of New Jersey, laid an iron wire, insulated with gutta-percha in the place of pitch and tar, in the waters of a small creek, and found that this substance afforded a marked increase in insularity. In the following year a similar line was laid between New York and Jersey City.

Lord Palmerston was much impressed with the reports of the success attending the foregoing experiments, as is evidenced by a prophecy he made in the House, that the time was surely coming when a minister, in reply to a question as to the existence of war in India, would say: "Wait a minute. I'll just telegraph to the governor-general and let you know." But few years passed by ere this prophecy was realized. Passing by the institution of two more cables insulated in gutta percha in the Hudson and at Kiel by Armstrong and Werner Siemens respectively, we come, in 1849, to another experiment carried out by Mr. West, already mentioned, with the same object in view. He judiciously chose a spot likely to become the locus in quo. He anchored the Princess Clementine some two miles off Folkestone, having previously connected the land ends of his cable with the 83 miles of line running by the Southeastern Railway's system to London, and successfully transmitted messages between the ship and the metropolis. The bait thus skillfully laid was swallowed. In the following year, 1850, a

cable was constructed under the supervision of Mr. John Watkins Brett, with a length of 25 miles. Delays of one kind or another intervened, and it was not until August that it was placed on board the steam tug Goliath. Owing to its having been left for a considerable time in an unsuitable place while sundry preliminaries were being settled, it was considered advisable for a careful retest before beginning laying operations. With this object sections were paid out from the tug, and Mr. Reid conducted the necessary experiments. It was found difficult to prevent the residents of Dover from multilating the cable, so anxious were they to secure a few inches of it as a keepsake. The astonishing ignorance displayed as to the damage their actions caused can be gaged by the objection made to such a length of cable on the ground that no one could pull so heavy a weight. At last, on August 23, the Goliath left Dover, convoyed by H. M. S. Widgeon for the purpose of giving soundings, and successfully laid the cable with shore ends terminating in the lighthouse at Grisnez. Connection was at once made with type-printing machines, and the current was plainly transmissible. The only drawback was that the words were absolutely unintelligible. The electricians at Grisnez somewhat uncharitably put this down to the naturally exalted feelings of the Dover operators having led them to the abuse of strong drinks—a supposition also held by these gentlemen as regards their colleagues at the lighthouse. We know now that the incoherency was due to nothing worse than retardation caused by induction.

The festivities attending the completion of the job were scarcely over when the cable failed to act altogether! At the age of about 24 hours it was found that the rough bottom had been too much for an unarmored line, and had worn away the gutta percha covering.

Undeterred by this failure, in the following year, 1851, another cable was constructed, which, in order to avoid the fatal consequences of friction, was composed of four copper wires twisted like an ordinary rope, covered with two coats of gutta percha and armored with ten heavy wires, so that it weighed six tons to the mile. Again delays occurred, owing to an injunction obtained by Messrs. Newall & Company, trade rivals of the manufacturers, but at last this was dissolved, and 27 miles of cable were stowed away on the Blazer, a government hulk, on September 25. She was towed by two government tugs, and laying commenced off the South Foreland lighthouse. All went well for some time, until it commenced to blow, when it was found that the brake which retarded too rapid emission of the cable was not acting quite satisfactorily, the result being that the line was all used up about a mile from Sangette, the French terminus. A temporary connection was made by utilizing a portion of a subterranean line intended to connect Sangette with Calais, and the customary congratulatory messages passed between the two countries.

In the following month the Red Rover tug attempted to complete the cable by adding the missing mile, and eventually did so after a long search for Sangette, which no one on board seemed able to localize with accuracy. Owing to a fault in a joint at the English end, communication was interrupted, but was soon restored. This may be regarded as the turning point in the history of submarine telegraphy; had this attempt been as unsuccessful as the prior one to connect two friendly countries, it is unlikely that the schemes for uniting Great Britain and America would have been seriously discussed for many years.

THE FUTURE OF AMERICAN INDUSTRIES.*

By A. E. OUTERBRIDGE, Jr.

GENTLEMEN: The letter which I recently received from Dr. Lindsay, requesting that I would speak to you on this occasion upon a subject which has occupied my thought, and with the practical side of which I have had daily contact—or at least cognizance—for several years past, states that you are "interested particularly in the kind and quality of labor employed in this country, and in the social significance of improved labor-saving machinery."

Two years ago I had the pleasure of addressing your predecessors in this class upon the subject of the "Educational Influence of Machinery,"† and one year ago on "Pending Problems for Wage Earners."‡

I purpose on this occasion to attempt to cast the horoscope of manufacturing industries in America for the opening of the new century. In so doing, I will venture to express some views which may not be considered entirely orthodox from the view point of the old-time manufacturer, who adheres tenaciously to the economic teachings of the fathers of American industries, and fails to see or recognize changed conditions which are plainly apparent to others. No one disputes the self-evident fact that the food which is adapted to babes is not sufficiently sustaining for strong men; so also, when our manufacturing industries were young and weak, they needed for their growth and development fostering care and protection from the attacks of older and stronger rivals; but now, when they have outgrown their swaddling clothes, and have, in some instances, become giants in stature, of Herculean strength, they are prepared to go forth and conquer in the impending peaceful battles for the commerce of the world. To do this they must break away from the leading strings of the good mother government, and fight with the superior weapons they have forged for themselves while under her care and tutelage.

It is my conviction that many of our industries have now reached this period of adolescence, or even of full vigor, and are well armed and prepared to explore new lands and to conquer new territories.

Advance couriers have already been sent "to spy out the land," and, if I may venture to claim any degree of prescience of the future, resulting from careful study of past industrial conditions, I would say that, with the coming of the twentieth century, new and greatly enlarged fields of operation will be opened up by energetic pioneers in trade, who will not hesitate to hew out new pathways for themselves, even though many laggards may eventually follow after at their leisure and avail themselves of the advantages which have thus been gained by the pluck and toil of the pioneers.

* An address to students in Economics and Sociology in the Wharton School of Finance, University of Pennsylvania (December 18, 1896), with some additions and omissions for this publication.

† Engineering Magazine, May, 1895.

‡ Popular Science Monthly and Jour. Frank. Inst., May, 1896.

Disclaiming any political significance or intent in the color of these introductory words, I desire to confine my remarks to a study of present industrial conditions and their indications, which are in some respects entirely unique, and, therefore, not yet fully comprehended by the majority of observers.

The ability to perceive, in advance of others, the gradual budding or unfolding of future events—that quality of mind or temperament which we commonly call foresight—is a rare one, and prophecies are always somewhat risque. I therefore ask you to recognize a difference between the value of the statistics and statements of fact here given and of the predictions regarding the future based upon these facts. The former may be accepted without hesitation, the latter with due caution, remembering that there are not a few manufacturers who would to-day surround this country with a sort of Chinese wall for the purpose of excluding the possibility of entrance of rival manufactured products, and, of course, thereby incidentally preventing export of our own manufactures to new markets.

This subject affords an interesting and never ending game of battledore and shuttlecock for political wranglers, in which we are not particularly interested; we will, therefore, pass over this phase of the discussion altogether.

The existing condition and future prospects of manufacturing industries in this country present interesting problems for study to the student, the statesman, the manufacturer and the wage earner.

It is evident, even to a casual observer, that many industries which have proved profitable in the past have been over-stimulated; improved facilities for manufacturing have outstripped the capacity for home consumption.

Competition has lowered prices, wages have fallen, production has been curtailed (more especially during the past three years) and hardships have resulted therefrom.

Further curtailment of production or else enlargement of markets must prove the solution in the near future of this important economic problem, and the key to the situation may, perhaps, be found in the recent reports of the Bureau of Statistics in Washington.

These statistics show that exports of American manufactures are increasing year by year, thus proving that we are now successfully competing in the markets of the world with the manufactured products of cheaper labor in foreign countries.

Although the complete returns for the year 1896 are not yet available, it is safe to estimate, from the figures furnished in the past eleven months, that the total exports of manufactures for the year will equal, if they do not exceed, $250,000,000. This will be about $50,000,000 more than in 1895, which figures were, in turn, about $25,000,000 more than those of 1894.

Subtracting from the total those items which do not involve elaborate mechanical processes (such as petroleum, copper ingots, etc.), it appears that about 70 per cent. of the value includes a great variety of manufactures in which skilled labor forms the largest element of cost.

These divisions include: Agricultural implements; sewing machines; typesetters and typewriters; watches and clocks; boots and shoes; locomotives and other machinery; machine tools and hardware; electrical supplies and scientific apparatus.

It has heretofore been maintained—and, indeed, is still contended—by many manufacturers, that the relatively high wages paid to skilled labor in America, as compared with wages in European countries, preclude the possibility of successful competition; but facts are more convincing than theories.

Within the past few years several large manufacturers, thinking to avail themselves of cheaper labor abroad, have established branches of their works in different parts of Europe; the same equipment of labor-saving tools and, as far as possible, the same systems of management were employed.

The result in each case proved a surprise. American labor, though highly paid, is so much more efficient that it has been thus shown to be cheaper in the end than that of poorly paid operatives in Europe. Several specific instances of this kind might be given if space permitted. Exact imitations of American manufactured products, including machine tools, have been made in France, but they have cost more to produce there than the importation of the genuine articles cost.*

It has been contended that freight rates on all heavy manufactured articles would surely always prove a prohibitive handicap. Facts again disprove theories. Two years ago an Alabama furnace sent an experimental shipment of 250 tons of pig iron to England. This was considered an "exceptional case," and was also pronounced a visionary project and derided as ridiculous in the extreme.

Within this brief period, says the Manufacturer's Record, the demonstration is complete,

"From that experimental 250 ton shipment this business has increased until now there is an actual scarcity of steamer room to handle the business offered. Orders are being booked every week for large shipments to England and to Continental countries. It is difficult to rightly measure the influence of this trade upon the world's commercial interests."

From a recent statement by an officer of a leading furnace company, the foreign orders booked by that company alone amounted to about 40,000 tons, and inquiries under consideration between 30,000 and 40,000 tons. One of these, the same day on which this information was given, covering 5,000 tons, materialized into an order.

Pig iron has already been shipped to Liverpool, Manchester, Rotterdam, Vienna, Genoa, Trieste, Yokohama and elsewhere abroad. These are facts not yet generally known.

Mr. John Fritz, in reviewing the history of the manufacture of pig iron during the past fifty years, at a recent meeting of the American Society of Mechanical Engineers, said that prior to 1840, when anthracite fuel was introduced in blast furnaces, the metal was nearly all made with charcoal, a good sized furnace of that day producing 15 to 30 tons of pig iron per week. In a lecture on pig iron, which I delivered before the Franklin Institute in 1888,* I called attention to the fact that blast furnaces were then producing 1,000 tons of pig iron per week, and still larger output might be expected in the future.

* See Engineering Magazine, January, 1897.

The Carnegie Company is now building an extensive new plant at Duquesne, Pa., and furnace No. 1 is already in operation. During the month of November this furnace produced a daily average of 572 tons of standard Bessemer pig iron, something hitherto unprecedented, and at the same time lowered the record with respect to proportion of fuel and cost per ton; 1,600 pounds of coke sufficed to smelt a ton of iron.

This company now controls ore beds of enormous extent on the famous Mesabi Range, in Minnesota, from which it obtains its low phosphorus iron ore at phenomenally low prices. It has taken from one mine alone—the Oliver—during the past year more than 800,000 tons, at a cost of less than twenty cents per ton, all charges included. The mining (so called) consists in scooping out the hillside with steam shovels and depositing the ore directly on the cars.

An idea of the capacity of this labor saving machinery may be gained from the recent statement of Professor Winchell that, in spite of certain unavoidable delays, "an output of 808,292 tons was made during the year with three shovels, one of which was idle about half the time."

The estimate of twenty cents per ton, here given, as cost of mining appears to be excessive, as Professor Winchell, who has itemized the factors going to make up the cost, states that the stripping charge per ton of ore, uncovered, does not usually exceed six or seven cents per ton, and the cost of shoveling the ore out of its natural bed, after stripping, does not exceed ten cents, and with a very large output may be less than half this amount.

Crude pig iron stands near the bottom of the list of articles involving a high degree of skilled labor. American watches, on the other hand, head the list. Yet they are exported, in constantly increasing quantities, to all parts of the world.

Very recently, the American consul at Bradford, England, reported as follows:

"One Bradford firm of jewelers alone has a stock of 20,000 Waltham watches. In addition, it has watches of the Elgin and other makes, and sells large numbers. American files, made by machinery, according to the testimony of Consul Meeker, compete with English hand made files. He mentions one order, recently sent to this country, for 1,000 dozen, whereas an order for 200 dozen English files would be considered, ordinarily, as a large one.

"Go into any cutlery or hardware shop in Bradford," said Mr. Meeker, "and ask for shears, and you will be handed a pair bearing a Newark or Trenton, N. J., imprint. They are considered superior in every way, and one of the strange things about it is that they must be purchased through Sheffield, which is supposed to be the rival of American cutlery manufacturers. These shears, a dealer said to me, are superior to all others, because they are 'sweet cutters.' The shears used by tailors and cutters are almost entirely of American make.

"Turbine water wheels and printing presses of American manufacture are also sold in Bradford."

The export of machine made boots and shoes is rapidly growing, and has indeed already assumed large proportions.

Within a few years past great improvements have been made in shoemaking machinery and in the product, accompanied by an equally noticeable reduction in cost.

Few persons are aware of the present extent of this business, which has grown up from very small beginnings. Statistics show that, in the census year of 1890, no less than 179,500,000 pairs of boots and shoes were made in factories in this country, by 194,000 operatives, an average of nearly 1,000 pairs per annum for each employe and an average of nearly three pairs of shoes for every inhabitant.

A single factory, employing 233 hands (chiefly girls), turned out 2,100 pairs of women's shoes a day.

The best qualities of machine made shoes are now fully equal to the best hand made shoes, and are produced at one-third the cost; this accounts for their favorable reception in a number of new markets, in spite of former prejudices and of occasional misrepresentations of rivals, who naturally fear loss of business.

Seven thousand tons of steel rails, besides enormous quantities of other railroad material, are now being made in Pittsburg for Japan, and large orders have, it is said, been booked for China.

A complete locomotive manufacturing plant was recently shipped from Philadelphia to Russia, and railroad machinery is now on its way from this port to Australia.

A multitude of similar illustrations could be given, but these will serve as straws to show the direction in which the "trade winds" are now blowing, and it only remains for American enterprise to take advantage of the opportunities which favorable circumstances offer to enter upon a new era of industrial prosperity.

The secret of success in these tentative experiments is to be found in the wonderful advances which have been made in labor saving machinery, supervised by intelligent, highly paid operatives, whereby the productive capacity of each employe is enormously increased and the cost per unit of product correspondingly reduced.

The possibilities of reduction in cost of manufacture of any given articles are not always appreciated first by those who are most familiar with the routine methods. New departures are apt to emanate from those who approach the problem from a new standpoint, unbiased by old traditions.

A striking illustration of rapid changes in methods, and concomitant great reduction in cost of manufacture, is furnished in the recent history of the evolution of the incandescent electric lamp.

In 1880, I visited Edison's laboratory at Menlo Park to inspect his new system of incandescent electric lighting.† I was then much impressed with the novel methods of making, in considerable numbers, the delicate lamps and filaments, and regarded them as marvels of mechanical ingenuity.

I understood, at that time, that Mr. Edison had suc-

* Journal of the Franklin Institute, March, 1888.

† For description, see Journal of the Franklin Institute, March, 1880.

ceeded by his methods in reducing the cost of manufacture of the little lamps one-half—i. e., from about $3 to $1.50 each.

To-day, lamps, far superior to the earlier forms made in 1880, are sold in large lots at less than twenty cents each! A single factory of the General Electric Company turns out 6,000,000 a year, and the output of all the factories combined is about 20,000,000 lamps per year.

It is interesting, in view of the present low cost of the lamps, to know that the carbon filament is estimated to be, weight for weight, the most valuable substance known.

Filaments for the ordinary 16 candle power lamps are worth $10 a thousand, and 14,000 are required to weigh a pound.

The filaments in the tiny bulb lamps used for surgical and dental purposes are very much smaller, and are three times more valuable if estimated by weight, or more than $400,000 per pound.

Formerly, it was customary to estimate approximately the cost of a locomotive at $1,000 per ton weight. Thus, an engine weighing 40,000 pounds would cost about $20,000. To-day, a first class locomotive, weighing about 130,000 pounds, costs about $8,000, or less than 6¼ cents per pound. Labor saving machinery and "piece work" systems of pay are largely accountable for these results.

The Pennsylvania Railroad has made an interesting, almost startling, discovery of the value of the piece work system of remuneration in its shops at Altoona, as compared with the "days' work" plan formerly in vogue.

An elaborate description of these methods, and of the results attained, may be found in the current number (December) of the American Engineer, Car Builder and Railroad Journal.

It is stated that, before the introduction of the new system, fifty new locomotives per annum represented the capacity of the shops. Since that change, the output—with substantially the same tools and appliances—has doubled. "The cost of days' work in the erecting shops of what are known as Class I engines was $290. The same amount of work on engines of the same general class, but about fifteen tons heavier, now costs $95.75, and is done in one-half the time. . . By days' work it took three days to build a box car. This work is now done in fifteen hours.

"The pipe work on a locomotive formerly cost $137, and now costs $32."

Figures are given, showing that, while the output has been doubled and cost of labor reduced one-half, wages have been raised more than 25 per cent. under the new system.

The value of this change may be better appreciated when it is stated that the cost of equipment on the Pennsylvania Railroad last year was $9,500,000, of which about $4,750,000 was labor.

In conclusion, I may repeat what I have said on a former occasion, that the introduction of labor saving machinery has enormously increased the output for each workman, and this introduces a new element into the ethics of the question of wages, and also into the practical question of cost. If it can be shown that a skilled workman, at a slight increase of labor and attention, can enormously increase the output of a machine, he should be encouraged to make the effort by an increase of pay.

An increase of output must logically and necessarily involve a fair increase of wages, and, in a properly conducted business, this increase of wages, following increased output, must mean increased profit.

This is a profit sharing scheme to which there can be no practical objection.

While the brief statements here given are intended merely as indications of the present and prospective condition of manufacturing industries in America, they seem to point clearly to the encouraging fact that this country is about to enter upon an era of industrial prosperity through growing expansion of its commerce and manufactures.

THE PERCEPTION OF SOUND.*

THE external ear is the least important part of the organ of hearing; it is composed of the pinna, which acts as an acoustic tube, and of the auditory meatus, a partly cartilaginous, partly osseous canal, which leads to the tympanum. Beyond this membrane lies the middle ear, which one may imagine to be a sort of drum furnished with four apertures, the largest of which is closed by the tympanum, whose other surface, through the auditory meatus, is placed in communication with the exterior air; in the opposite wall is found the round window (fenestra rotunda), while nearly above it lies the oval window (fenestra ovalis), both equally shut off by exceedingly delicate and elastic membranes; the only opening not entirely closed being the Eustachian tube, a species of conical canal, placing the middle ear in connection with the pharynx, into which it opens with every movement of deglutition. Within this drum is found the curious chain of ossicles stretching from the tympanum to the fenestra ovalis; it comprises four small bones, to which names that recall their shapes have been applied: the hammer (malleus) is fastened by its handle to the center of the tympanum; after it comes the anvil (incus); then an almost circular little bone, named the os lenticularis; and finally the stirrup (stapes), whose base almost entirely covers the fenestra ovalis.

By these two windows, or openings, the middle ear communicates with the external ear. And now we arrive at the marvel. This is the internal ear, or labyrinth—a hollow cavity in the most resistant osseous section of the cranium (the so-called rock), filled entirely with a transparent liquid, the vitreous acoustic humor. The internal ear is composed of the vestibule, in direct communication with the fenestra ovalis; of the cochlea, a cartilaginous organ reminding one of a snail in shape; and of three semicircular canals or passages. In the peculiar liquid that it contains floats a kind of membranous sac connected with the osseous wall only by a few blood vessels and minute bundles of nerve fibers that pass through the liquid. In the vestibule, as well as in the cochlea, the microscope reveals a multitude of tiny strings or filaments, which are nothing more or less than extensions or ramifications of the extremity of the acoustic nerve, or of nerves subserving it; and these minute organs bear the names of the savant Schultze, and those of the cochlea the fibers of Corti.

So then, perhaps somewhat too summarily described, behold the instrument. Now let us turn our attention to it at work.

A vibration reaches the external ear, at once producing in the auditory meatus a condensation followed by a dilatation. The tympanum is thrust inward, then drawn outward (such membranes as this adapting themselves to every species of vibration); while through the chain of ossicles the quivering traverses the middle ear and is communicated to the fenestra ovalis. The liquid in the vestibule begins, in its turn, to stir, as well as that in the cochlea, and by its vibrations solicits those of the fibers that it bathes; yet only such of these as possess a period of vibration corresponding to the initial sound, or to one of its harmonics, respond to the call; for each of them is attuned to a different tone.

The fibers of Schultze and Corti constitute a grand yet microscopic harp, whose every string is in sympathy with its special sound and transmits the sonorous impression to the brain along the acoustic nerve, whereof it is an expansion.

Now that the general action of the auditory apparatus has been sketched in a broad way, it is proper to revert, somewhat more in detail, to each of its organs in particular, if only to establish the utility of all of them, to show that there is not one too many, and to emphasize the great simplicity that underlies their apparent complexity.

Of what use is the Eustachian tube? With each movement of deglutition, every time that one swallows one's saliva, it partly incloses, permitting the air within the middle ear to maintain itself in equilibrium with the outer air; for without so perfect and constant equilibrium of pressure the membrane of the tympanum would not be in so good a condition for receiving vibrations. So true is this fact that when, by awkwardly sneezing, for instance, one accidentally compresses the air within that organ, the tympanum is momentarily swollen, a buzzing in the ear follows, and the hearing is affected, all being again set right by the first movement of normal deglutition.

The membrane of the fenestra ovalis, placed as it is between a liquid and a gaseous body, presents a less favorable condition for vibrating than that of the tympanum; hence the usefulness of the chain of little bones, which, stretching between these membranes, shakes them mechanically; and it merits remark that the point of attachment of the first ossicle to the tympanum is directly in the center of the same—that is, at the point of maximum vibration. Perhaps, were one to remove the ossicles, the sound would be transmitted anyhow through the air within the drum, yet it would certainly be with a relatively very great faintness; for, by means of the chain of ossicles, the tympanum commands the fenestra ovalis.

We have not yet discovered the purpose of the fenestra rotunda. To understand it one must consider that, in the act of audition, the liquid within the inner ear, being influenced by the vibrant air contained within the auditory meatus, is constantly undergoing molecular dilatation or condensation; if at every point without exception its walls were inflexible, it would either burst them or not vibrate at all, since there can be no vibration without elasticity. So, to allow the liquid mass to oscillate synchronically with the membrane agitating it, it must somewhere find another elastic surface to yield to its pressure, and this requirement is answered by the fenestra rotunda, placed between the inner and the middle ear.

The number of fibers constituting what we would call the sympathetic harp may appear excessive; yet through the microscope as many as 3,000 have been counted, and it is certain that there are more. But let us stop at these 3,000. Helmholtz sagaciously observes that, in estimating at 200 the sounds situated beyond musical limits, and whose height has been only imperfectly determined, there remain 2,800 fibers for the seven octaves of instruments of music—that is, 400 for each octave and 33⅓ for each semitone, enough at any rate to account for the perception of fractions of semitones within the limits of its actual occurrence.

As for the transmission to the brain by the auditory nerve of sonorous impressions, there is no reason to wonder thereat more than concerning an infinite number of analogous physiological phenomena. The network of nerves intersecting our bodies has been often compared to a network of electric wires, and the comparison is quite warranted.

Through all those wires there circulates only one fluid, the so-called electric fluid; nevertheless, some convey power, others transmit speech, and yet others diffuse light, all depending upon the various kinds of apparatus placed at their extremities or within their circuits. Likewise our nerves, the conductors of the nervous fluid, according to the organ wherewith they are connected, convey to the brain, the central station, sensations of taste, smell, touch, sight and hearing. But the admirable part of it all, though science explains it, is the marvelous faculty of the human ear for decomposing and analyzing, with the precision we have just remarked, the vastly complicated movements of vibrating air, while dealing with so minute a portion of air as that which comes in contact with the tympanum. Nevertheless, it is evidently in this way that the phenomenon of audition is produced.

Admitting that the ear perceives clearly all sounds between 32 and 8,448 vibrations a second, we must understand that the number of sounds really existing within those limits cannot be expressed by any figures. The more delicate, better constituted and better exercised an ear is, the better will it succeed in dividing and subdividing the space in question, in apprehending and estimating the slightest differences; hence, the appreciation of the degree of sensitiveness of the hearing, in differences of intonation, is extraordinarily variable. In the noise made by the wind on a stormy day in a chimney, or among the reeds, the sound rises and falls without interruption through divers heights; now, in the endless number of values that the elevation of sound may take in thus continually varying, there is no degree that we can fix upon and make a point of comparison. No ear is capable of perceiving amid such a succession of sounds (one at every instant) any precise degree of intonation. It is simply musical material in the rough.

*Translated from the French of M. Albert Lavignac by William Struthers, in the Home Journal.

A FIREPROOF TREE.

By G. CLARKE NUTTALL, B.Sc.

THE wonderful adaptability which a living organism can show to an apparently hostile environment has been a matter of remark times without end. Again and again we have been struck by the presence of life where we should least have looked for it, and have been surprised by the marvelous way in which certain forms of life can become modified to enable them to grapple successfully with new contingencies. Indeed, this adaptability to environment is the sign proper of life, and on it alone has it been found possible to frame a satisfactory definition of the term itself.

A new and striking instance of this power of adaptation has recently been brought into notice by a government report issuing from Colombia, the northwest corner of South America. Writing from Sante Fe de Bogota, the chief town, Mr. Robert Thomson draws attention to a native tree which is capable of withstanding the action of fire to a most remarkable degree; indeed, it apparently prefers to be exposed to it, for it actually thrives better when it has been "under fire." This quality enables it to live where other trees perish, as the following will show. A great part of Colombia and the north of South America generally consists of level plains almost interminable in extent, known as llanos or savannas, and estimated to cover nearly three hundred thousand square miles, an area more than three times as large as the whole of Great Britain. Here and there at long intervals low hillocks or mesas break the monotony of the plain, but so little are the inequalities of the surface that the llanos have often been likened to a sea of land. During the dry season of the year they become veritable deserts of dried up vegetation and burning sand; the wild animals sustain life with the greatest difficulty, and the parched earth cracks into deep fissures. With the advent of the rainy season Nature revives: the plains spring into life, both animal and vegetable, the waters pour down, the rivers swell, and soon what had been a desert becomes a lake of rolling waters over which boats may pass for miles. Animal life suffers almost as much then from the too great abundance of water as it previously did from the drought. When the waters subside in October they are followed by a paradise of fresh green vegetation, which springs up into maturity almost like magic; and the inhabitants of the plains, the Llaneros, come down from the low hills where they had retreated during the flood, driving down with them their vast herds and flocks to feed on the juicy pasturage. For a time all is well, but gradually the sun sucks up the moisture, the vegetation withers and then dies, and the drought again settles on the land. The herdsmen are accustomed at this time, when everything is as dry as tinder, to set fire to the heated grass, so that when the rains come a new growth shall spring up unhampered by profitless remains of a past season.

These savanna fires, miles in extent, sweep over the plains with devastating fury, destroying all in their path and leaving behind them only a track of blackened ashes, which ashes, though giving back to the soil the elements which the plants took from it, do not enrich it to the same degree as would accumulations of leaf mould formed from decaying vegetation. What is a gain in utility as far as pasturage is concerned is a loss in other ways, for the fire entirely checks the growth of trees or shrubs, and the land is bare of vegetation beyond the yearly yield of grass.

One tree alone stands out a solitary and striking exception to the havoc wrought by the flames. It refuses to go under in the general devastation, and so well has it known how to protect itself, that the fire leaves it unscathed; nay more, it has made the best of its lot, and bends the very flames to its service. Locally this tree is known as chaparro, botanically it is classified as Rhopala obovata. It belongs to a genus of trees and shrubs most of which are also natives of South America. Its appearance is much what we should expect from one whose whole development has been a struggle against desperate odds. It is dwarfed in stature, rarely exceeding twenty feet in height, and its stunted trunk does not measure over a foot in diameter.

Its rugged branches are twisted and bent into grotesque shapes, which speak plainly of a mute, sullen resistance. The leaves clothing the branches are coarse, rough, and hard in texture. The flowers grow in small spikes, insignificant and without beauty; they have no need to appeal to the eye of either man or beast. Each flower produces two seeds in a leathery, podlike case; the whole tree is built on a resistant plan. Each seed is a flat oblong, and has attached to it a membranous wing. The flowers develop after the rainy season, and the seeds mature during the great drought. When the fires rush over the plains the pods have burst, and the hot currents of air catch up the little winged seeds and carry them along, scattering them far and wide. Thus the tree effects its aim—the dispersal of its seeds through the agency of the flames; and the short exposure to the heat does not injure their dry, tough nature. The presence of wings in seeds which rely on the wind as a carrier is not at all uncommon; the pine, for instance, provides its seeds with a comparatively large wing, and pine seeds are often carried great distances. When the chaparro seeds germinate they are found to have been scattered in wonderful order and without crowding, a result probably due to some regularity of the flame currents, and the plantations that form are most noticeable for the systematic arrangement of the trees; in fact, they have every appearance of having been planted and kept by man's agency. This is a fact which strikes particularly on the attention, for so often where Nature is left to herself we have terrible overcrowding and a most desperate battle for the survival of the fittest.

Why is this tree so remarkably adapted for the fight with fire? The secret lies in the peculiar bark which covers it like a skin. Bark arises on trees from the dried up outermost tissues of the stem being rejected and pushed off, as the stem, in its natural course of growth, forms new tissue from within. In no trees has the outer portion of the bark any organic function; when retained it always serves a purely protective purpose. In the chaparro this outer bark, to the thickness of about half an inch, is arranged in loose layers, and it has become thickened and modified to such a degree that the protection against ordinary dangers is extended to the case of fire. In addition to being practically fireproof, its arrangement in the loose layers renders

it a non-conductor of heat, and therefore the delicate inner tissues of the tree remain unharmed during the scorching but brief onslaught of the savanna fire.

The home of the chaparro is emphatically these fire-swept plains. In Colombia its plantations cover vast areas; they are found touching the sea coast on the north and again a thousand miles inland; they may be on the level plain or high up on the surrounding hills at an elevation of a thousand feet or more. It is at a disadvantage, however, in situations where other trees can live; it can defy the fire, but it succumbs in a struggle for existence with others of its kind. All its energy appears to have gone in the fight with its one particular foe.

The natives of Tolima, one of the United States of Colombia, credit the chaparro with yet another virtue. They assert that it will only grow where there is gold in the soil below, and that, therefore, it serves as a true guide to the seeker after riches. This belief, however, rests at present only on tradition, for though it undoubtedly grows in auriferous regions, it has yet to be proved that it grows in no others.

This humble fireproof tree is bestowing great benefit on the land, and is slowly improving it. The plantations are a protection against the fierce rays of the sun, for under their shelter it is not possible for the land to be so parched; moreover, they attract what little moisture there is in the air, and so the chaparro plantations, during the dry season, almost play the part of oases in the desert. Mr. Thomson points out that the chaparro's work in the amelioration of the land might easily be accelerated and extended, were man to step in and assist nature by a "few simple devices."

The chaparro is not the only tree which can resist, to a very great extent, the action of fire, though, probably, to no other is the fire so congenial, and, therefore, it may be fairly claimed as the "king of fireproof trees." Certain euphorbia trees, close allies of the chaparro, have been noticed in Africa to survive the grass fires with only a few scorches. It was surmised that here too the secret of their immunity lay in their bark, and specimens were submitted to Professor Farmer for examination. His report confirmed this idea. In it he states that all pieces submitted "agree in possessing cells which show a certain amount of gummy degeneration of the cells in the bark, together with the presence of a considerable amount of sclerotic cells;" and his conclusion is that "it seems not impossible that these two facts may be connected with the resistance of the plants to the fire."—Science Gossip.

ROLE OF THE NERVES IN THE MIND CURE.

The influence of the mind over the body as a factor in determining certain phases of health or sickness is acknowledged by all physicians just as they acknowledge the potency of any other agency, whether external, as exercise, or internal, as opium, aloes or any other drug. They simply object to the adoption of any one of these agencies to the utter exclusion of all others, whether the favored agency be mental action, muscular movement, or some special drug. So far as the action of the mind is effective, it is so through that remarkable system of nerves called the "great sympathetic." The functions of these nerves and their influence in controlling the physical organization is well set forth by Dr. A. J. Park, of Chicago, in an essay on "Mind, Prayer, and the Supernatural in Healing," which he first read at a meeting of "The Round Table" in that city. The Literary Digest quotes the part in which he treats of this particular subject:

"The class of nerves involved in such derangements as affect the bodily organs is the great sympathetic system, which has dots as reservoirs (called ganglions) all through the human organism where nerve force and nerve currents are generated and stored, and by its network of fibers constituting a telegraphic system of infinite sensibility which dwarfs all human contrivances and preserves a uniform and equal degree of temperature and sensibility throughout the body.

"The nerves of sensation and the nerves of motion occupy a very subordinate position, though closely allied to the sympathetic system. The nerves of sensation are the messengers which convey to the sensorium every sensation and impression, pleasant or painful, that is made upon the cutaneous shield; and every impression thus received and transmitted carries with it a voice from the great sympathetic. Hence, it will appear clear, upon a little reflection, that the sympathetic nervous system presides like a monarch over the feelings, emotions, and sensations of every human being; that, as its uses and powers are vital to life, so are its normal functions essential to mental equipoise.

"The absolute and despotic control that the sympathetic system exercises over the physical organization is so perfectly clear and well known to every observer that the recital of the phenomena in the vast and countless series of its manifestations is unnecessary. We are all practically aware of the fact that digestion is promptly arrested upon the receipt of bad news—the appetite at once disappears, it ceases, and the whole system feels the effect of the depressing impulse, the mental or spiritual wave which lowers the vital thermometer.

"Fear not only suspends the digestive functions, but arrests the formation of the secretions upon which digestion depends. A sudden fright frequently paralyzes the heart beyond recovery; whereas, a pleasant and pleasing message soothes and gently excites the whole glandular system, increases the secretions, aids digestion, and sends a thrill of joy to the sensorium, which diffuses the glad tidings to every nerve fibril in the complex organization.

"In view of these physiological and anatomical facts, it is perfectly clear how it is that the method of cure known as massage, or the Swedish movement cure, cheerful conversation and earnest prayer, send to the sensorium of the invalid a new and fresh array of impressions. A vigorous and energetic rubbing of the body excites the capillary system, imparts renewed life to dormant nerves, invigorates the expiring and lifeless cells, enables the weak and flagging energies of the system to throw off effete matter, revivifies the sluggish circulation, increases the heart's action, and arouses the flickering and vacillating will up to the level of manly resolution and higher hopes—and herein lies the whole secret of the so-called faith cures."

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